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American Practice in Electric Traction.

MANAGERS and engineers of electric tramways, together with municipal councillors and others interested in tramways and their development, will find much useful information in the various papers which were read at the twentieth annual meeting of the American Street Railway Association, which was held in New York in October last. They were published in various technical journals at the time, and are now available in a more convenient form for reference in the recently published report of the Association.

The papers are of very unequal merit; but, taken as a whole, with the discussions, some valuable lessons may be learned from them, both from the engineering and from the managerial point of view, more especially the latter. We shall consider under their several headings the points worthy of notice, taking first questions of general management, and afterwards those of engineering practice.

Municipal Ownership.

There has been a certain amount of popular clamour in the United States for the municipal ownership and operation of electric tramways, but R. McCulloch, the General Manager of the Chicago City Railway Company, and the author of the first paper read at the meeting, stated that he was only aware of one State where it had even been made possible by the necessary legal authorisation, and there it had utterly failed of fruition—seemingly from the impossibility of agreement between the different municipalities. He was strongly of opinion that no city in the States would have attained its present state of development if its transportation facilities had been as limited as the best hitherto obtained under municipal control.

Another speaker on this subject, C. S. Sergeant, Vice-President of the Boston Elevated Railway Company, pointed out that street railways in the United States had long since outgrown municipal boundaries, in the sense of one company being confined to one municipality, and that they were now rapidly outgrowing the State boundaries. His argument was enforced by reference to the fact that the rate of interest which had been earned upon the money invested in tramways of municipalities in Great Britain had been extremely small, while the facilities afforded had been most inferior to those enjoyed in the United States.

Inter-urban Service.

With regard to the financial and working arrangements to be made between the city and interurban companies, there was much conflict of opinion, but on most of the salient features of interurban service there was a very general agreement. The importance of a high-speed interurban service was universally insisted on, and the advisability of supplementing the ordinary day service by one of morning and evening express cars for business men—an arrangement which had been greatly appreciated in the case of the town of Cleveland, and, in consequence of its success there, was likely soon to come into extended use. The speakers generally were agreed upon the importance of continuing the high-speed service right into the business centres of towns, as otherwise it was almost impossible to avoid a block at the points of change. It was agreed that it is preferable, where possible, to run the cars right through, in place of the interurban passengers having to change into the city cars. The great difficulty in the way of a continuous interurban and town service lay in the necessity which it involved of a special route for the high-speed cars. In some cases it was possible to purchase land for private roads, but side streets could generally be utilised.

A similar system would be much appreciated in this country; and in most provincial towns it could be carried out in much the same way as in the United States. In the more congested parts of London and of our large provincial towns the only feasible solution would appear to be the construction either of subways or elevated tracks for the high-speed traffic. Instances of speeds in these interurban street railways in the United States were given as high as 55 miles an hour maximum speed, the average speed in this case being over 40 miles an hour.

Uniform *v.* Graduated Fares.

The system of uniform fares generally adopted in the United States was considered greatly preferable to the graduated system which is most prevalent elsewhere. Mr. Sergeant maintained that the small fare for short distances has neutralised, wherever it has been in use, the benefit which would otherwise have been experienced, as far as large towns are concerned, in breaking up the slums which are the inevitable concomitant of the abnormal confinement of the poorer classes in densely populated areas.

Results of Improved Transport Facilities.

The beneficial result of the improvement in transport facilities in the towns of the United States and their suburbs, due to the development of the street railway system, has been of a far-reaching character, as, in addition to the relief of the congested centres of population, with all its train of consequences in diminishing crime and improving the conditions of life among the poorer classes, these improved transport facilities have assisted in the development of trade, increasing the number of customers of the places of business in the towns, and of visitors to the theatres and other places of entertainment, and bringing greater prosperity to the surrounding country by widening and cheapening the outlets for their produce.

Carriage of Freight.

The carriage of freight by means of street railways between the towns and villages received a considerable amount of attention at the meeting of the association, and it was stated that many street railways companies were already carrying on this traffic with success. Mr. Nicholl, of Rochester, stated that, in order to meet the wishes of the public, their freight cars were made so as to resemble passenger cars in external appearance. They have windows along the sides just like the latter, and they can be used for passengers if required; but they are also furnished with large doors in the sides for the purpose of loading and unloading freight.

Standardisation.

From the engineering point of view some few questions of interest were discussed, the most important one being that of standardisation.

With the growth of the interurban system of street railways, increasing inconvenience has been experienced from the numerous patterns of wheels and rails in use, and from the obstinacy of the engineers of small municipalities, many of whom are both ignorant and incapable, in insisting on the use of special sizes and patterns on the sections which they control. With a view of finding a remedy for this evil, a Committee of the Association was appointed in February, 1901, to consider the question of standardising street railway equipments and materials, and their report is, from the Traction Engineer's point of view, by far the most important, we might almost say, the only important result of the meeting. The report contains recommendations with regard to rails, wheels, axles, journals, journal brasses, brake-heads and shoes, journal boxes, car bodies, and the general electrical and overhead equipment.

The most noteworthy recommendation is that of a T-rail of special section, which, as experience has shown, can be operated without interfering with the pavement in towns, and with safety on suburban roads, at a minimum cost for track maintenance.

Signalling.

The paper, by W. Pestell, on "The Adoption of Electrical Signals on Suburban and Interurban Railways, of Single or Double Track, and their Economy of Operation," will also be of interest to our traction engineers in the near future, as the extension of our electric tramway

system will soon make an organised signalling system imperative; and so far, in this country, the only experience which our engineers have to draw upon, is with railways having their own exclusive permanent way.

Other Points.

Systems of transmission are discussed, and the orthodox recommendation is given that the best method, for lines of any considerable length, is to employ three-phase transmission, with rotary convertors in sub-stations. One cannot help wondering, however, why such a subject as "Alternating and Direct Transmission on City Lines" was not entrusted to an electrical engineer familiar with the subject, instead of to a railway manager, who frankly states that he had informed the Association, that he was not an electrical engineer, and had had no experience with alternating currents; but, in reply, was asked "to present the subject, at least, in such a manner as to bring forth a profitable discussion by the members of the Association." This, however, it did not succeed in evoking. We learn, from a paper by J. H. Vail, that cooling towers are coming into extensive use in the States, in connection with power stations; and some figures of interest are given in connection with their working: arguments are brought forward, in the same paper, in favour of the use of pulverised fuel. In another paper, the use of storage batteries in power stations is discussed, and attention is called to the fact that storage batteries act as very efficient lightning arresters; but the paper mainly traverses well-trodden ground.

We should like to see the report in the hands of every municipal councillor in Great Britain who is likely to have any influence in connection with any scheme of electric traction. Those who would most benefit by its lessons, if they would only lay them to heart, are—Firstly, the municipal councillors, who could do so much to assist in the development of electric traction, if they could only be induced to abandon the Little Pedlington point of view, and loyally support our traction engineers, who know both what to do and how to do it, if only they can obtain a free hand; secondly, those half-trained, or less than half-trained, municipal engineers who attempt to disguise their ignorance by insisting upon fads of their own, but only succeed in bringing their incapacity into fuller view; and last, but perhaps not least, the ordinary educated public who wish for improved facilities, and are only too ready to join in an outcry against British engineers because of the backwardness of our country in the utilisation of Electric Tramways, but have never realised that this backwardness is due almost entirely to their own apathy, in suffering the industry to be hampered, as it has been, by legislative burdens and restrictions of the most onerous character.

The Industrial Peace.

An attempt is being made in New York to devise means that will effectually prevent the recurrence of strikes, by providing an acceptable tribunal that can hear all matters arising and adjudicate upon them. The committee formed for this purpose is composed of thirty-six members, drawn equally from the ranks of employers, labour, and the general public, so that it is hoped all sections interested are represented. A meeting was held recently, when the following statement was adopted unanimously as representing the objects sought, the principles and purpose that they had in view:—

"This committee shall be known as the Industrial Department of the National Civic Federation.

"The scope and province of this department shall be to do what may seem best to promote industrial peace; to be helpful in establishing rightful relations between employers and workers; by its good offices to endeavour to obviate and prevent strikes and lockouts; to aid in renewing industrial relations where a rupture has occurred.

"That at all times representatives of employers and workers, organised or unorganised, should confer for the adjustment of differences or disputes before an acute stage is reached, and thus avoid or minimise the number of strikes or lockouts.

"That mutual agreements as to conditions under which labour shall be performed should be encouraged, and that when agreements are made the terms thereof should be faithfully adhered to both in letter and spirit by both parties.

"This department, either as a whole or a sub-committee by it appointed, shall when requested

act as a forum to adjust and decide upon questions at issue between workers and their employers, provided in its opinion the subject is one of sufficient importance.

"This department will not consider abstract industrial problems.

"This department assumes no powers of arbitration unless such powers be conferred by both parties to a dispute."

The general tenor of the speeches illustrates the fact that our American friends fully realise the difficulties that follow in the train of these industrial conflicts, and that the best interests of their country will be served if they can succeed in preventing strikes altogether. To those who are interested in the discussions that are in progress concerning the methods and ways of trade unionists in this country, some of the remarks made at the meeting by Mr. Schwab (President of the United States Steel Corporation) are very interesting, for they show that the mischievous policy of the labour leaders in this country have their parallel on the other side of the Atlantic. Mr. Schwab said :—

"My attitude upon the labour question is too well known to need discussion here. But I did come here, as Bishop Potter well expresses it, to see the other side of the shield if I can. Any man who is as largely and as deeply interested in labour as I am must try to see the other side of the shield, to see the question of labour from the employers' as well as the employés' point of view. I am here with a mind open to conviction, with a mind to receive anything that is fair, with a mind to do that which is fair, to bring about harmony between capital and labour.

"It is a selfish motive in a way. I realise that the prosperity of the United States is going to advance more rapidly. It is bound to advance, at any rate. But it is going to advance much more rapidly when this happy solution has been reached.

"The decadence of trade in many of the old countries is due primarily to the attitude which labour has taken with reference to capital. It is the most important thing with reference to the loss of trade in Great Britain to-day. I think that all economists writing upon this subject will agree with that. I don't mean to say that employers have not been arbitrary and radical. They have. On the other hand, I think that labour has been just as arbitrary and radical. And it is to remedy these differences that we ought to get together.

"There is one point that I want to impress upon you—that labour unions will never succeed, as trusts never succeeded, in the attempt to restrict the output, or attempt to put any restriction upon trade in general. Those great trusts that are formed in a business way to control the output of any commodity, to raise the price, they all have failed, and all will fail. A trust will succeed where there are motives of consolidation for economy's sake and for regulating the trade generally. And the labourers must take a similar position.

"Labour must not restrict the output. That is a fundamental principle. And I am sorry to say that every labour organisation with which I have had experience in the past has had as its foundation the restriction of the output. It is that principle that is putting English commerce and English trade in the bad position they are to-day, and we owe it to America's greatness in commerce that these great business aggregations do not become trusts, and that the labour leaders must not put them in a position where the labour union becomes a trust of time and output.

"I am opposed to labour organisation as it is to-day organised. I am sorry that I did not have Mr. Phillips and such gentlemen to deal with. I think that only good will come from a frank and naked discussion of the truth, and therefore I give you these views. I should not be opposed to organised labour if organised upon correct principles. It is a mistaken idea that manufacturers are opposed to labour unions *per se*. They are opposed to them as they do exist, not to labour organisations that keep their contracts, not with labour organisations who will not restrict the output, not with labour organisations who have the good of the trade at heart."

The frequent reference by Mr. Schwab to the conditions that obtain in this country show how very closely our commercial position is being studied by the 'cute Yankee with the intent to profit by our difficulties. In it will be found much that will repay careful consideration, and, taken together with some of the results that are being obtained from British workmen should convince any who may be inclined to think that the charge of "restricted output" is not proven.

The controversy that was carried on in the columns of a contemporary was naturally followed abroad very closely, and some attempts were made to draw lessons from the facts that were disclosed for the benefit of our competitors; and amongst the comments those in a recent issue of the *Railroad Gazette* cannot be pleasant reading for the labour leaders in this country or for their champions the London County Council. The editor remarks: "That Trades Unionism in England has gone mad, is common knowledge; but examples of the results of the spread of the peculiar methods of the leaders are not uninstruc-

tive to our own people. and we note two items which we find in recent London papers. A petition was recently presented to the Board of Trade by the London County Council, asking for four new suburban trains on the North London Railway, to be run between the hours of three and five o'clock in the morning, which petition was said to have the support of 857 working men. But the railroad company, after getting the names of 159 of the alleged petitioners and making inquiries, found that 100 of them could not be traced; that in 32 cases the persons were dead, or had removed, or the street number could not be found; and that only 27 were correct. Col. Yorke, who had charge of the case on behalf of the Board of Trade, on learning this state of the facts, immediately discontinued the inquiry. The representative of the County Council admitted that the officers of the Council had been grossly deceived. Of course the Trades Unions concerned in this case will not have to pay the costs incurred by the Council or the railroad company. An article in *The Times*, showing some of the mischievous results of what is done on behalf of the Trades Unions, gave interesting details of how the Trade Union axiom, that a workman must be careful not only to refrain from working too long, but also from working too hard, has affected the railroad field. The flower of this idea is only found in shops where mechanical work is done by men connected with old and thoroughly organised Trades Unions; where, in some cases, a man who could easily finish fifty brass castings in a day is bound by his agreement to only finish eight. But railway employés appear to be good learners in this school. One energetic workman, while loading coal as fast as he could, was told by his mates that he 'mustn't work like that;' but he still kept on, and he got a black eye. A station-master who asked for more help at his station was told that he had as many porters as formerly, and that the traffic had not grown, replied that 'the men won't work as they used to do.' It appears that signalmen and other railroad employés who have had their hours reduced now devote their additional leisure to shoemaking, gardening, plastering, and other work, which, of course, may interfere with the prospects of a livelihood formerly enjoyed by men who depend on these occupations for their daily bread. This last item suggests a highly interesting query in the American sociological field: What use is being made of the extra hour or two daily which thousands of artisans, mechanics, and labourers now enjoy over and above the time which was at their disposal a few years ago?"

Following these are some comments upon the speeches made at the meeting of the committee mentioned above, and the remarks of Mr. Schwab are commended as being "the most useful," although Bishop Potter, Archbishop Ireland, and Mr. Hanna "uttered admirable sentiments." But, the editor adds, "The speeches of the professional labour leaders were not encouraging. They threshed over old generalities, and revealed their wilful blindness to the facts. They showed no sign of growth in knowledge or thought. So long as the unions keep fetters on the intelligence, enterprise, and thrift of the individual they are at war with the laws which are at the root of human progress, and so long they are a threat to society. It would be a pretty *good plan to send a few deputations of working men to England, and to give them a chance to see with their own eyes the logical working out of the restrictive idea of the Trade Unionism.* Perhaps Mr. Schwab and Mr. Hanna, and a few other very rich men, may think it worth their while to raise a little fund to carry out this little scheme." The italics are ours, and we commend the idea to the careful attention of all those who are still inclined to sympathise with the Trades Unions, for it is so very suggestive. Whilst we are busy sending deputations across the Atlantic to see how things ought to be done, they are contemplating the necessity of sending deputations to this country in order to convince their working men of the individual and national dangers that the idiotic policy of the present-day Trades Unionism will, if persisted in, inevitably lead them into.

Inventors and Manufacturers.

A CONSIDERABLE amount of public interest has been aroused by the suggestions set forth and discussed in our issues of December and January last, pointing out the desirability of forming an association of leading manufacturers and technical experts, with the primary object of utilising for the national benefit some portion at least of the great stream of inventive talent which is now, from one avoidable cause or another, running to waste. Both the letters which the editor has received and the large number of expressions of opinion which have appeared in leading organs of the press show, beyond room for doubt, that we have given voice to a deeply and widely felt need. Many of them have contained valuable and instructive suggestions and friendly criticisms, while others have merely expressed appreciation of the effort which we are making to promote a movement of which the need has been deeply impressed upon our minds. This was not put forward by us without long and careful consideration, and we cannot but be gratified by the cordial and widespread approval which our proposals have evoked.

There is one fact which has been driven home to the minds of our manufacturers by numerous sharp lessons received during the last few years, and that is that, whether for good or evil, individualism and isolated effort cannot hope to hold their own against the great combinations, either of rival interests abroad, or of associations antagonistic to progress at home.

We have put forward as the primary object of the proposed association, the facilitating of the improvement of manufacturing processes by bringing the manufacturer and the inventor into closer contact, to the great benefit of both parties. The effect of such a union of interests would not only be to utilise those inventions and improvements which would be of value if made known and adopted, but would tend to direct the flow of inventive energy into the channels where it would be most useful, and at the same time stimulate it by the improvement which it would effect in the prospects of the inventor.

While insisting on the importance of placing these facilities at the disposal of the manufacturer, we have not lost sight of other obstacles than want of knowledge of possible improvements, to his introduction of such improvements into his factory. These further difficulties were touched upon in the article entitled "Problems before British Manufacturers," which appeared in our last issue, and they, together with other problems pertaining to the manufacturer's interest, would naturally come within the scope of such an association as we have proposed, provided it were established upon the firm and broad basis which we should desire.

We have purposely in these articles confined our attention to the broad principles which we desire to put forward, because we consider that the details of the scheme can only be properly worked out when those who are sufficiently interested in it to become its pioneers have met, and discussed the ways and means of developing what is, at present, only an outline sketch for the plans and working drawings, so to say, which must precede its practical realisation.

Our Lost Speed Supremacy.

WE suppose it is hardly necessary to inform any reader of this magazine that we *have* lost our railway speed supremacy, absolutely and completely, and that we now occupy third place, and a very poor third, with the United States and France completely running away from us. That, we take for granted, everybody even casually interested in railway matters knows by this time.

Bearing in mind the fact that as recently as ten years ago our railway speed was unexcelled, the growing requirements of heavier trains have not been met by an adequate increase of locomotive power. True, the British locomotive has grown in the last decade, but in no way commensurate with the weights to be hauled, and the additional power needed has been

met by the uneconomical and make-shift expedient of using two locomotives. In considering the question of growing requirements as regards locomotive power, why not face the problem, not with a compromise, *i.e.* an engine that can barely meet the requirements of the day, as has been done in nearly every case, but with a machine that can meet all demands of the special work it is designed for, and still have a reserve of power for anything the future may reasonably hold in store for it.

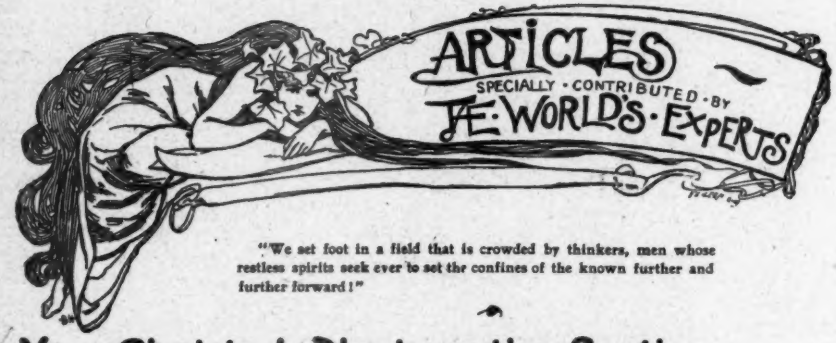
Perhaps the most extraordinary feature in connection with the drawback we are hampered with, viz., a more restricted dimensional limit than any of our great rivals, is the fact that our British locomotive designers as a body have failed to make use of the only too limited space at their command, and without which adequate power is mechanically impossible. This apparent timidity and endless repetition of old designs for an ever-increasing volume of work to be done is inexplicable. An exception must be made in the case of Mr. Aspinall of the L. and Y., who has demonstrated with his "1400" class of express engines what can be done with the limited space at our command. These engines came as a complete revelation of dimensions and power to most people, with their boilers over 17 ft. long, 4 ft. 10 in. in diameter, and centre line pitched 8 ft. 11 in. above rail level, thus ensuring ample fire-box space, to say nothing of tube-heating surface. The triumph of this design is made doubly great from the fact that Mr. Aspinall chose to make use of driving wheels (7 ft. 3 in.) of greater diameter than any other modern designer of coupled express engines is using, and yet get over them a boiler that for size and steaming power eclipsed anything ever attempted in Great Britain. Without claiming that the design of the "1400" class is an ideal type for the fastest and heaviest service in this country, it is, nevertheless, invaluable as an object-lesson in extreme dimensions, and, above all, shows clearly that if such a boiler can be used with driving wheels of maximum diameter, how much more lung power can be given our locomotives by a comparatively slight reduction in wheel diameter (say 6 in. from the above, viz. 6 ft. 9 in.) and consequent increase in the size of boiler, should it become necessary, without detracting from the speed qualities in any way.

In the L. and Y. engines we possess a type capable of attaining high speeds with the heaviest loads, a type that we should like to see tried with the 300 tons West Coast express. There is still a chance for a British locomotive to do unexcelled work, but not by looking shyly at improved methods for ten or fifteen years after everyone else has adapted them. There is nothing in the latest American and French locomotive designs that our engineers cannot easily equal.

Vibration on Tube Railways.

THE report of the Committee appointed for the investigation of the causes of vibration on tube railways has at last been submitted to the President of the Board of Trade—the Right Hon. Gerald W. Balfour—and will be followed with the closest attention. As a result of the careful examination made, it was found to be, as expected, that the gearless locomotives were responsible for the complained-of disturbance, this arising from the high unspring-borne weight carried on each axle. It will be remembered that last year this Committee's observations (made in connection with the Central London Railway) led them to see that the entire difficulty arose (*a*) from the large proportion of the weight of the locomotive not spring-borne, and (*b*) to a want of rigidity in the rail. Unfortunately, the contemplated test with a different rail was unable to be carried through, but it was possible to obtain a new type of locomotive or to adopt the multiple-unit system. In the case then under consideration complications arose

from the fact that the weight on the axles of the locomotives was not altogether responsible, and, further, in the absence of reciprocating parts, it was not possible to assign the cause to imperfectly balanced machinery. It was found that, provided that the tires were perfectly circular and the rails perfectly straight, and so supported as to yield equally everywhere to the passing load, there would be nothing to account for the vibration. In the present instance, it was discovered, however, by making careful measurements, that the principal source of the oscillation lay in the unevenness of the surface of the rails. On quitting the rolls these are generally curved, and, despite the process of straightening by local bending beyond the elastic limits, a certain waviness invariably remains. Accordingly, when the unspring-borne portion of the load follows the rail along these waves, certain vertical accelerations inevitably occur, causing the pressure on the supports to become changeable. Thus, when springs are absent, and the speed fairly high, the pressure of the rail momentarily disappears, and the load is on the point of "jumping" the hollows of these waves, whilst the portion borne on springs moves almost in a horizontal line without following the waviness at all, the pressure on the corresponding rails remaining almost uniform. It appeared that the irregular impulses given by these uneven rail surfaces established and maintained oscillation of the rails and road bed, this being regarded as an elastic support loaded with unspring-borne burdens. It was furthermore noted that the greater part of the vibrations were equally frequent, although the train producing them was purposely run at different speeds. The experimental locomotives and trains equipped on the multiple-unit system before mentioned, were built by August. In the locomotives the original type was adhered to, except that gearing was introduced to obviate the mounting of the motors directly upon the driving axles. The unspring-borne load was consequently reduced in like ratio, amounting to $2\frac{1}{2}$ tons on each axle, as against the 8 tons on each axle of the older type. This new kind, of which there are three varieties, is known as the "geared" locomotive. In the train fitted on the multiple unit system the motors were carried at one end of two or more passenger cars, so that in this case the unspring-borne load on each axle of the truck under the motor was only $1\frac{3}{4}$ tons. The tests made with the geared locomotives and multiple-unit trains showed the anticipated improvement, the vibrations decreasing in proportion to the unspring-borne load. For the geared locomotive they were less than one-third, whilst for the motor-car train they were actually less than one-fifth of the vibrations caused by the old locomotives. The superiority between the two new types was considered to lie with the motor-car train, the passages of the geared locomotives being slightly felt in several instances, whilst in no case was the former experienced on its journeys. As a result of their investigations the Committee unanimously recommend the adoption of a type in which the unspring-borne load is reduced as far as possible, which may be arrived at (*a*) by using gearing (*b*) or motor carriages, (*c*) by the use of the gearless locomotive in which an elastic connection is employed between the driving-axle and the motor. They did not, however, enter upon any tests with this last. For the Central London Railway the adoption of the motor cars, in place of the old locomotives, is recommended. The Committee, however, expressed themselves as having little doubt that any method of driving in which the unspring-borne load is reduced to a similarly small quantity might also be used with satisfactory results. Whilst having no positive evidence to offer on the question of the most preferable form of rail or sleeper, they announced their predilection in favour of a somewhat stiffer and deeper rail than that used on the Central London Railway. In drawing up their report the Committee were much assisted by interviews and consultations with Sir Benjamin Baker (engineer to the Central London Railway), Sir Douglas Fox, and Mr. W. R. Galbraith, Mr. A. Mallock being employed for conducting the details of the work.



"We set foot in a field that is crowded by thinkers, men whose restless spirits seek ever to set the confines of the known further and further forward!"

New Electrical Plant on the South-Eastern and Chatham Railway.

By W. N. TWELVETREES, M.I.Mech.E.

ATTENTION is frequently directed to the South-Eastern and Chatham Railway system by aggrieved passengers and others, who presuppose the absence of intelligent management or of proper consideration for the welfare of the travelling public. We very seldom find any appreciation of the efforts that are undoubtedly being made to provide suitably for the large and rapidly-increasing demands due to augmented traffic and to progressive ideas of comfort. That such efforts have been and are being made is evidenced by extensive additions to the permanent way and rolling stock, and in no small degree by the works and admirable electrical equipment which form the subject matter of the present article. The installation in question was designed by and executed under the supervision of the consulting engineers, Messrs. Kirkland and Capper, MM.Inst.C.E., of 17, Victoria Street, Westminster, and has proved to be most efficient and economical after some eighteen months of continuous work. Another noteworthy feature, and one which we are particularly pleased to mention, is to be found in the fact that the machinery and plant generally are almost entirely of British manufacture.

The works are situated at Slade's Green, in the vicinity of Erith, and include a central generating station, locomotive and engine repairing sheds, offices, and a small colony of workmen's cottages. All these buildings, together with the passenger station and adjacent streets, are lighted by electricity furnished from the generating station, connections being also made for a new hotel and business premises in the neighbourhood. The power-house and other buildings cover an area of about two-and-a-half acres, and the locomotive sheds provide accommodation for the large number of 120 locomotives, the general arrangement being indicated by the plan contained in Fig. 1.

In describing the establishment it will be convenient to commence with the generating station. The dimensions of this department and the general arrangement of the different sections were determined by the engineers; but the architects, Messrs. Humphreys-Davies & Co. were responsible for all matters relating to building design and construction. The disposition of the buildings will be understood by reference to Figs. 2, 2*a* and 2*b*, where it will be seen that a siding

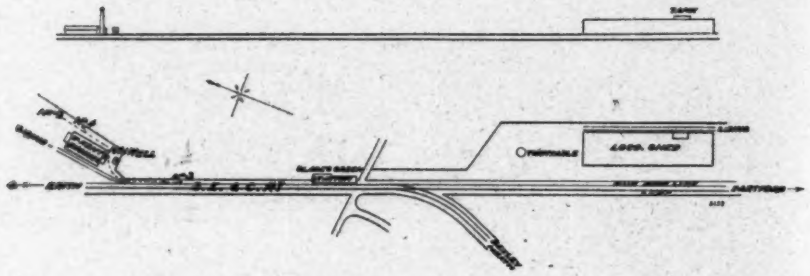


FIG. 1.—GENERAL PLAN OF WORKS.

from the main line runs along the outer wall of the coal bunkers where there is a platform for the purpose of facilitating the direct delivery of coal. Next to the coal store is the boiler-house, which at present contains two water-tube boilers of the well-known Babcock and Wilcox type. These boilers are furnished with superheaters, and are capable of evaporating 10,000 lbs. of water per hour at a pressure of 160 lbs. per square inch. A simple yet very convenient feature in the arrangement of the boilers is that the back ends of the steam drums pass through the wall separating the boiler-house from the engine-room ; and as duplicate steam and water gauges are provided, the engineer in charge is able to exercise supervision over the work of the stokers without leaving the engine room.

Each superheater, is placed in a situation where there is a temperature sufficient for imparting from 100 degs. to 150 degs. of superheat, and as it is not subject to the direct action of the fire, variations of stoking cause very little fluctuation in temperature when the boilers are in regular work. Whilst steam is being raised overheating is guarded against by a device for flooding the superheater with water from the boiler. This operation is effected by means of a three way cock and a connection with the water space of the boiler drum, and thus whenever desired the superheater may be filled through the lower manifold to the boiler water-level. Any steam formed in the tubes finds its way through the collecting pipes to the steam drum, and before commencing to use the superheater the water is drawn off by the flooding pipe. All the tube joints are expanded, and the tubes themselves are of "U" shape, connected at the terminals with manifolds, whilst the bends are left free to provide for expansion Products of combustion from the boilers pass through a Green's fuel economiser of 72 tubes, built with by-pass flues, so that the waste gases may be led directly to the chimney if it should become necessary to shut down a portion, or the whole, of the economiser for cleaning or repair. The mechanical scrapers by which the outer surfaces of the tubes are kept free from accumulations of soot are actuated by a half-horse power Lundell electric motor.

Sufficient space has been provided for the installation of eight more boilers and additional economiser tubes, and the chimney shaft, measuring 110 ft. high by 7 ft. 6 ins. diameter, has sufficient capacity to deal with the contemplated extension of the steam generating plant.

A general view of the engine-room equipment is given in Fig. 3, in which may also be observed the ends of the boiler drums already mentioned.

The two generating sets shown in Fig. 4 each include a Willans & Robinson three-crank compound central-valve high-speed engine, driving a four-pole Bruce-Peebles dynamo developing 100 kilo-watts at 450 revolutions per minute, and capable of regulation so as to generate at any required pressure between 450 and 500 volts, the main cables being arranged on the three-wire system. Messrs. Willans & Robinson's engines are so well known, and have already been so fully described in our columns, that detailed comment is

not necessary in the present case, but we are pleased to be able to pay a tribute to the workmanlike character and satisfactory running of the electrical machines furnished by Messrs. Bruce, Peebles & Co. Although of comparatively recent origin, this firm has already secured a reputation for well-made and efficient machinery—a result which is probably due in some degree to the adoption of entirely new and modern machine tools and labour-saving appliances in the equipment of their works.

On the platform at one side of the engine room are two electrically driven boiler feed pumps made by Messrs. Hayward, Tyler & Co., each capable of dealing with 1,500 gals. of water per hour, and driven through spur gearing by 6-h.p. electric motors of the Lundell type, furnished with rawhide pinions that not only reduce noise but are beneficial to the machines as they cause less vibration than ordinary gearing. Current can be supplied to the motors from either side of the mains, a method of connection that enables the load on the circuit to be balanced to a certain extent. At the present stage the full output of the pumps is not nearly approached, and the armature of the motors has been double-wound so that speed may be regulated between the limits of 50 to 700 revolutions per minute. An important advantage secured by this arrangement is that the pumps can be run at a sufficiently slow speed to maintain a continuous supply of feed water proportionate to the actual steam consumption.

Whilst dealing with the power house it will be appropriate to describe the water supply system, because it bears a direct relation to some details of the mechanical plant. The source of supply is found in four tubular wells, sunk by Messrs. Le Grand & Sutcliffe, and their positions are indicated in Fig. 1.

During the construction of these wells some interesting facts were noted which serve to illustrate some of the problems not infrequently encountered by water engineers. On this particular site, the soil extends to an average depth of 15 ft. below the surface, and the chalk formation is then entered. Curiously enough, no water was found in the overlaying gravel, although plentiful supplies are obtainable near the surface in the immediate vicinity. It was also observed that the yield of the different wells varied considerably as to quantity and quality.

Well No. 1, with a diameter of 8½ ins. and a depth of 273 ft. yielded about 1,560 gals. per hour at the depth of 260 ft., and 2,500 gals. per hour after a part of the tube lining had been removed.

Well No. 2, of 4 ins. diameter, situated at a distance of 300 ft. north from No. 1, furnished 1,600 gals. per hour at a depth of 250 ft.

Well No. 3, also of 4 ins. diameter, and placed 350 ft. south from No. 1, yielded 2,500 gals. per hour at 250 ft. deep.

And well No. 4, about 150 ft. north of No. 1, gave a supply of 3,000 gals. per hour at the depth of 200 ft.

In addition to these important differences, the hardness of the water was found to vary to a remarkable extent.

The fact that several springs in the neighbourhood should have been tapped within so limited an area clearly indicates the existence of "faults," and it is not improbable that these may be responsible for the absence of surface water, by permitting it to pass away to lower levels.

All four wells are connected by branches with a common suction pipe, each branch being furnished with a stop valve so that any individual well may be shut off as desired.

The quantity of water pumped from the wells is about 1,000,000 gals. per week. The water is delivered over the gilled pipes of a Ledward condenser, and, being collected in a tank beneath, passes through a Doulton softening apparatus into storage tanks, and is finally pumped into a 150,000-gal. tank situated on the roof of the locomotive shed rather more than half-a-mile away. The course of these several steps may be partly traced on the plan and section reproduced in Figs. 2 and 2*a*, and the disposition of the condenser and water softener is made clear by Fig. 5.

The main suction pipe from the wells is connected with two Worthington steam

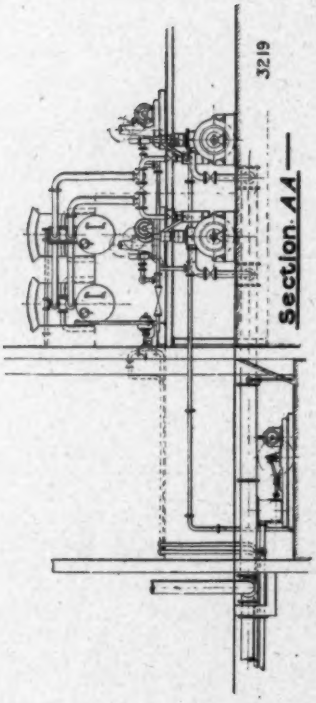


FIG. 2A.—SECTION THROUGH GENERATING STATION.

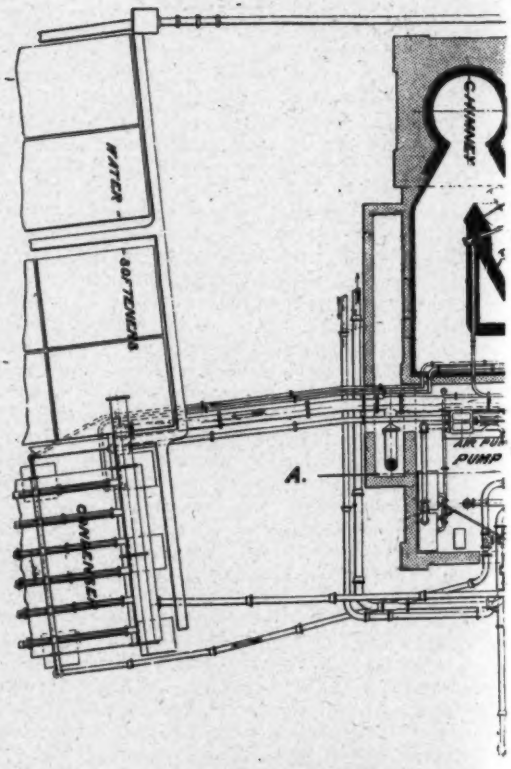


FIG. 2.—PLAN OF GENERATING STATION.

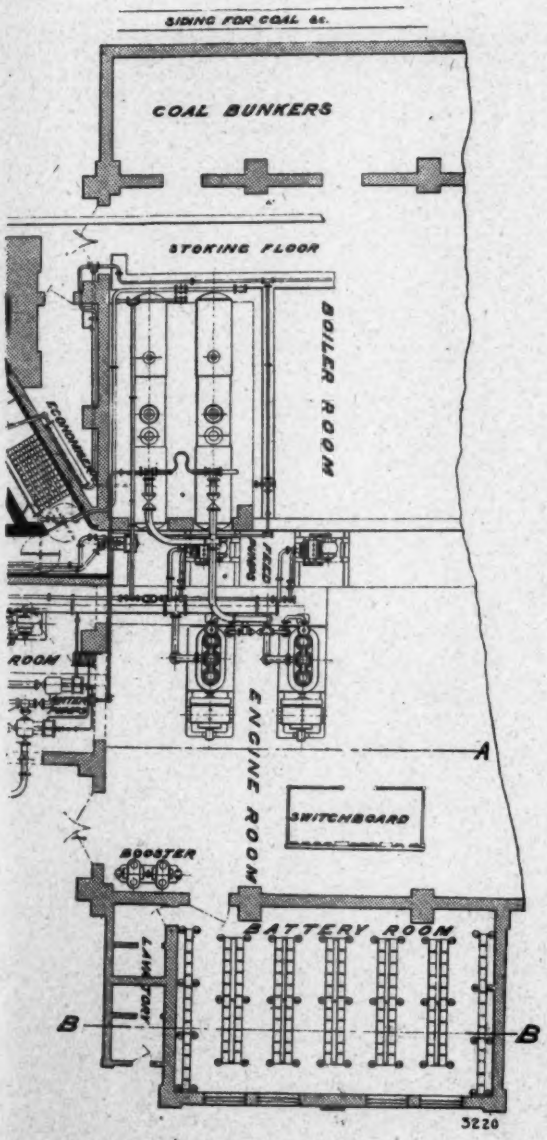


FIG. 2.—PLAN OF GENERATING STATION.

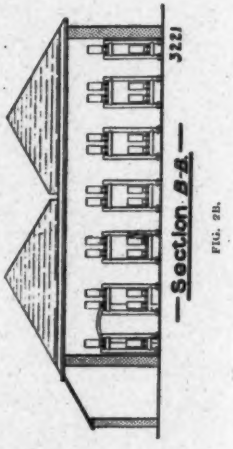


FIG. 2b.

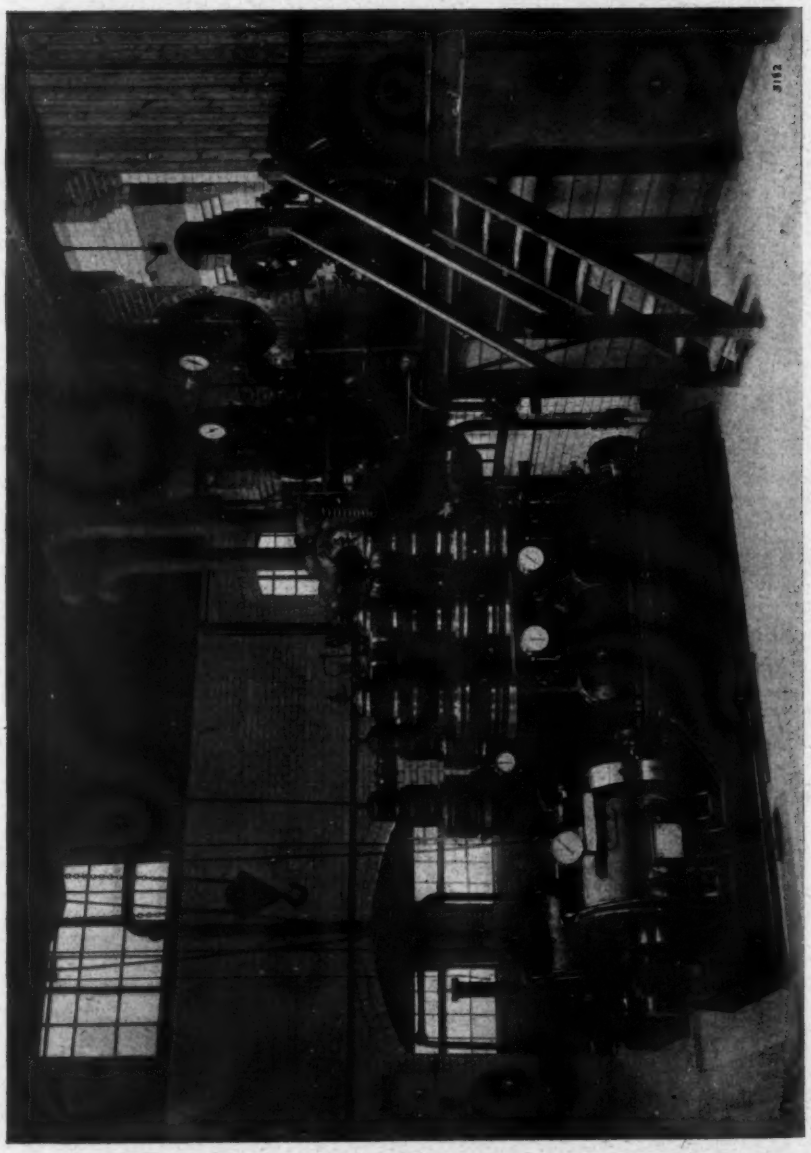


FIG. 3.—VIEW OF ENGINE-ROOM EQUIPMENT.

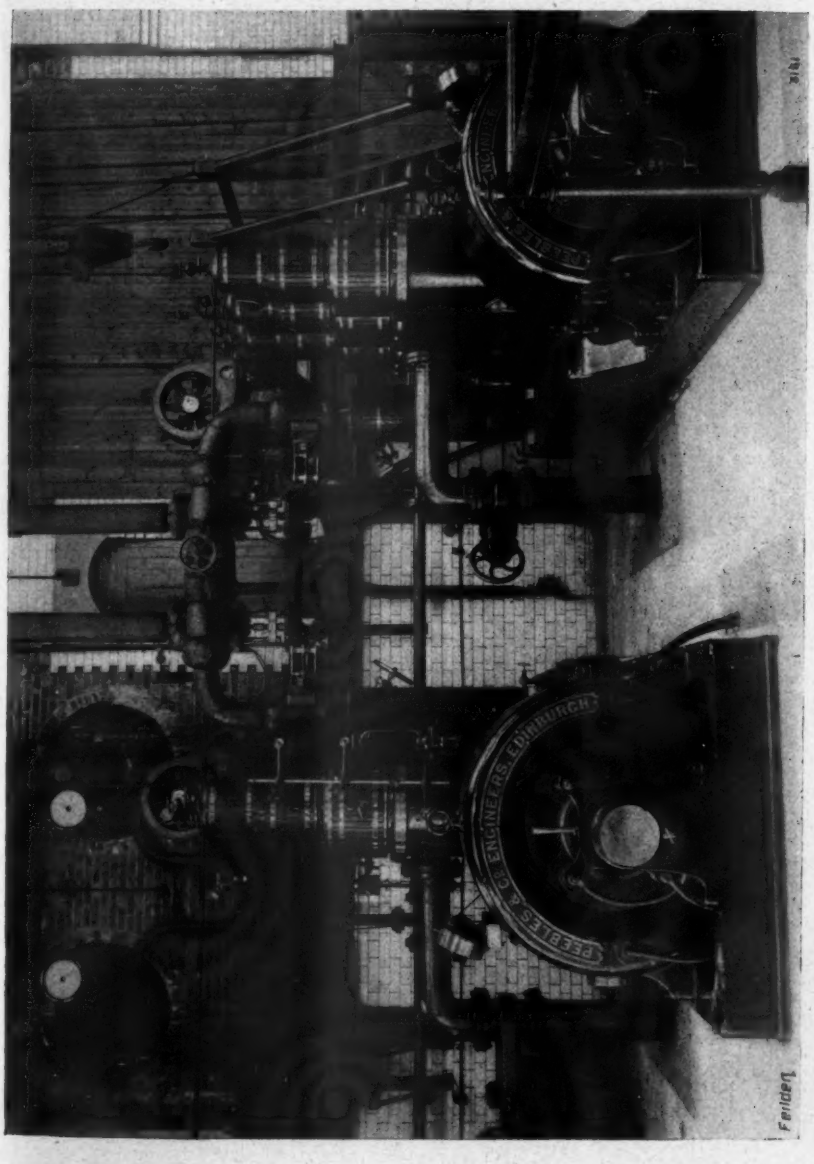


FIG. 4.—GENERATING SETS.

FIG. 5.—EXTERIOR OF GENERATING STATION SHOWING CONDENSER AND WATER SOFTENER.

pumps, situated in the pump room shown in Fig. 6, and the pumps duplicated in such a manner as to be available for pumping as described above, or directly from the wells to the 150,000 gals. storage tank. Each Worthington pump is of the duplex type, with 6-in. steam and 8½-in. water cylinders, and is capable of delivering 20,000 gals. of water against a head of 86 ft. through 940 yds. of 8-in. pipe, when working with steam at a pressure of 130 lbs. per square inch.

The condenser is of the Ledward evaporative type, a form of apparatus that is specially applicable in cases where water for condensing has to be paid for according to the daily consumption. In connection with an evaporative condenser the only loss of water is by evaporation, and the weight so lost rarely exceeds two-thirds of the weight of steam condensed. At Slade's Green the water pumped from the wells is utilised for condensing purposes, being allowed to trickle over the pipe surfaces in the manner already mentioned. The apparatus is composed of 180 gilled pipes, fitted so as to form six coils arranged in sections connected by piping, and placed in connection with the exhaust steam from the engine at one end and with an air pump at the other. A vacuum of about 26 ins. of mercury is maintained in the pipes, and the exhaust steam gives up its heat to the film of water on the outer surfaces of the pipes. Owing to this transference of heat, the steam is condensed, and is discharged by the air-pump as in the case of an ordinary surface condenser. From the collecting tank below the condenser the water softener is supplied, and it should be noticed that the collecting tank serves the additional purpose of aiding the deposition of suspended mineral salts thrown out of solution by the liberation of carbonic acid gas by the heat imparted to the water during its passage over the coils of the condenser. This

tank has an outlet connected with a centrifugal pump driven by a direct-coupled electric motor, this arrangement being for the purpose of maintaining the circulation of water over the condenser surfaces in case pumping from the wells should be temporarily interrupted.

The water-softening plant is of the type made by Messrs. Doulton & Co., and is in duplicate, each set being capable of dealing with 6,000 gallons per hour. As may be seen from Fig. 5, there are two circular tanks, in which water is clarified by sedimentation after it has been mixed with lime and soda in certain defined proportions. Lime is mixed in the upper tanks, each of which is furnished with a rotary stirring apparatus actuated by a waterwheel. Soda is kept in solution in a small cistern, and both reagents are mingled with hard water entering the softener, the quantity of lime and soda solution being automatically regulated by the flow of the incoming water. Clarification is effected in about one hour, but as some minute particles still remain in suspension, the water is passed through sponge filters before entering four storage tanks with a combined capacity of 12,000 gallons. From these tanks the softened water is pumped through a 6-in. Tylor's patent rotary water meter to the main storage tank above the locomotive shed, the height of water being indicated in the engine room by an Elliott water-level recorder and indicator, which indicates and records changes of level at every two inches.

Exhaust steam from the main engines and from the Worthington pumps is conveyed to the condenser by the pipe line shown in Fig. 2, and a by-pass pipe exhausts into the atmosphere when the condenser is not being used. At the foot of the vertical exhaust pipe a tank is connected for the separation of oil. Water is delivered from the hot well into feed tanks by a Ledward air pump of the

FIG. 6.—INTERIOR OF PUMP ROOM.

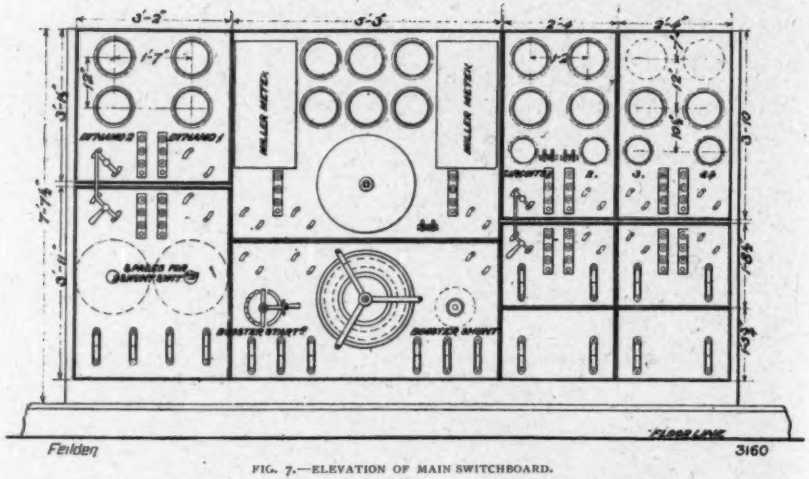


FIG. 7.—ELEVATION OF MAIN SWITCHBOARD.

horizontal pattern, driven by a 6 h.-p. Bruce Peebles motor by means of spur gearing. The feed tanks are in duplicate, and are graduated so as to afford means of checking the consumption of water by the engines.

The steam mains are of steel, those between boiler and boiler being of 6 ins. diameter, to the engines 5 ins. diameter, and to the Worthington pumps 1½ ins. diameter. The whole of the services are duplicated in the manner shown by Fig. 2, so that either boiler or main or any branch pipe may be shut off without interfering with the operation of the machinery. The valves required are few in number, and all are of comparatively small size. All exposed steam pipes and other steam surfaces are protected by magnesia non-conducting material.

By the brief sketch given above, it will be seen that the pipe systems and the machinery employed for the water and steam services have been most carefully thought out, and although details of the kind may not appear to be particularly striking to the casual observer, they are nevertheless of the utmost practical importance, a point that most of our readers will be fully prepared to recognise.

In considering the general features of the electrical equipment, it may be convenient to remark that the installation provides for the supply of power in the generating station and in the locomotive sheds, for arc lighting on the works generally, and for incandescent lights at Slade's Green station, the workmen's cottages, and adjacent property. The three-wire system of wiring is that adopted by the engineers, the engine-house wiring specification giving 230 volts and 460 volts between the outers. The dynamos are connected across the outer wires, and the centre wire is connected between the two sides of a double set of accumulators, each set comprising 88 ordinary and 50 regulating Tudor cells, the accumulators having a total capacity of 324 amp.-hrs. at a three-hour discharge, and an emergency output of 200 amps. for half-an-hour. The cells are ranged in double tiers on timber stands mounted on porcelain oil insulators, and glass insulators serve to support the separate cells. At the centre of each set are situated the regulating cells, which are charged by a double-wound two-pole booster balancer, made by Messrs. Mackie & Co. These details are illustrated in Fig. 2.

The main switchboard, of which Fig. 7 is an elevation and Fig. 8 a diagram of the connections, was made by The Alliance Electrical Co., and includes

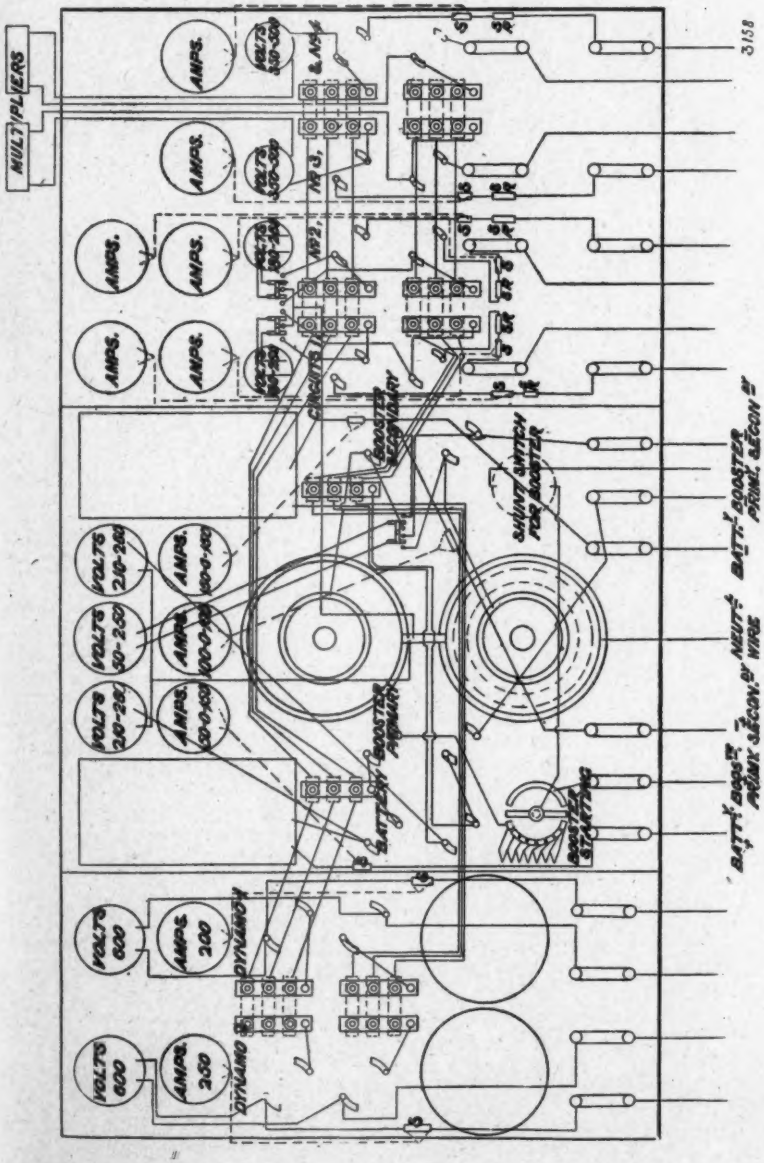


FIG. 8.—DIAGRAM OF MAIN SWITCHBOARD.

six panels; one for each dynamo, one for the battery, and one for each outside circuit. The equipment of instruments is very complete, as the following summary will show:—Dynamo section: 2 each Weston round pattern voltmeters and ammeters, 2 pairs of 3-way bus connecting bars, 2 d.p. 200 amp. tandem switches, 4 s.p. 200 amp. cutouts, 2 dynamo shunt switches. Battery section: 3 each round pattern voltmeters and ammeters, 2 Aron Miller meters, 2 32-way compound battery regulating switches, 3 tandem switches, 6 cutouts, 1 booster starting switch. 1 pair of 3-way bus connecting bars, 1 2-way voltmeter switch, 1 shunt switch. Distributing section: 6 round pattern ammeters, 4 "K" type voltmeters, 4 pairs of 3-way bus connecting bars, 4 tandem switches, 8 cutouts, 2 voltmeter switches. Behind the switchboard there are 2 double-circuit recording ammeters, 2 single-circuit recording ammeters, and 2 recording voltmeters. Future extensions of the board can readily be made at any time, and the switchboard is fixed at a distance of 5 ft. away from the wall of the engine room to afford space for the recording instruments and for examination of the connections. Pilot wires run from the farthest points on the circuit to the voltmeters, and a charge and discharge meter of the Aron Miller type connected to each accumulator set is adjusted so as to return to zero when the cells have been charged with ten per cent. more than the output. Three circuits are taken from the main switchboard to the locomotive sheds, and one circuit to the engine house, the railway station and workmen's cottages being supplied by suitable branches. The main cables are concentric paper-insulated, lead-covered, and armoured, as made by the British Insulated Wire Co., and were laid direct in the ground beneath the 6-ft. way of the main line; the branch mains are of the Callender type, laid on the solid system by Messrs. Callender & Co.

The extent and distribution of the lighting system will be gathered from the following notes. There are 30 arc lamps of 1,200 candle-power in the main locomotive shed, 15 of the same power in the repairing shop, 10 similar lamps in the yards adjacent to the sheds, and 5 other arc lamps in the stores and offices, all these lamps being connected with the 460-volt mains. In addition to arc lamps there are 31 incandescent lamps of 16 candle-power and 32 candle-power in the generating station, besides 12 wall-plugs for connecting up lamps for cleaning or inspecting purposes, over 150 incandescent lamps of 16 candle-power in the locomotive and repairing shops, besides connections for portable lamps. At Slade's Green station there are 29 incandescent lamps on single and double posts for platform use, and 40 lamps in the offices and waiting rooms. About 440 incandescent lamps of 8 candle-power are fitted in the workmen's cottages, and connections have been made for a number of incandescent lamps in the hotel and other buildings adjoining the premises of the railway company. The workmen's cottages each contain from four to six rooms, and each cottage has incandescent lamps in three of the rooms. The platform lights at the railway station are under control by switches, so that the full light is only on when required for passenger traffic, whilst at other times there is only one light on alternate posts. All the other lights in the station buildings are upon an independent circuit, governed by one main switch and the requisite complement of local switches. Simplex tubing was employed generally in the wiring, but where reason existed to fear the penetration of water or moisture, solid drawn steel tubing with screwed connections was used. Electrical plant for the operation of machinery has already received partial notice, and the remainder will most conveniently be described in connection with the equipment of the locomotive and engine repairing sheds.

Taking the locomotive shed first in order, it should be stated that the total length is 600 ft., and the width 120 ft. The design of the roof and glazing is well adapted for the admission and diffusion of light during the day-time, and the arc lamps, hung in six rows, are spaced so as to constitute an admirable substitute for natural light. In

FIG. 9.—INTERIOR OF LOCOMOTIVE REPAIRING SHED.

the inspection pits, where artificial light is always essential, there are connection boxes with projecting sockets for the attachment of portable lamps. The engine-repairing shed is about 315 ft. long by 30 ft. wide, and is lighted by side windows and alternatively by arc lamps suspended from the roof. Part of the shed is furnished with benches and inspection pits, and along these, lamp brackets of a special pattern, designed by the engineers, are furnished, having one fixed light and an additional socket, into which a portable lamp or a flexible connection for a drill-motor may be plugged. Fig. 9 gives a very good idea of this department.

The most striking feature in this shop is a pair of 25-ton electric travellers, built by Messrs. Jessop & Appleby Bros., each traveller being actuated by three Bruce-Peebles 12-h.p. motors, one motor for each motion. The travellers are of identical design, each having a longitudinal travel of 315 ft., a transverse travel of 28 ft., and a total lift of 20 ft. The speeds of the three motions are:—Longitudinal, 100 ft. per minute; transverse, 40 ft. per minute; lifting 3 ft. per minute at full load, whilst at lighter loads the speed is correspondingly increased. The motors are carried on brackets attached to the crab frame, and are controlled from the cage. The form of automatic brake with which the travellers are furnished consists of a wooden shoe, pressed against a grooved wheel by means of powerful spiral springs acting upon levers. These levers are also connected with an armature plunger under the influence of a solenoid magnet, so that when current is passing through the latter the brake shoe is held away from the grooved wheel, and as soon as the current is interrupted the armature is immediately released, and the brake comes into action. The motors are series-wound, speed being regulated by the aid of controllers and resistances in series therewith, and the switch to each has "off" and "on" positions and

arrangements for reversing. The main circuit is furnished with an emergency switch, placed within easy reach of the operator in the control cage. Current for the lifting and transverse motions is picked up by collectors from four trolley wires fixed on insulators below the beam, and two similar wires furnish current for the longitudinal motion. All these wires are in communication with the 460-volt circuit, and guards are fixed to prevent accident in case of the breaking of the collecting cables.

FIG. 10.—ELECTRICALLY-DRIVEN COAL-CONVEYOR.

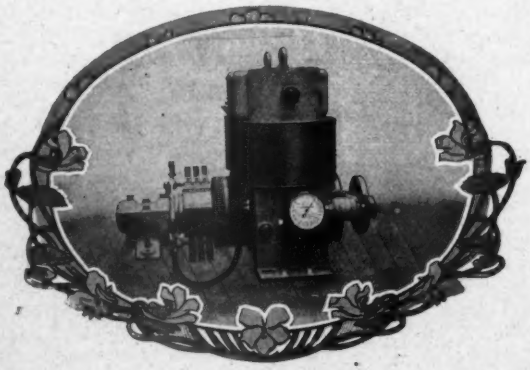
A portion of the shop is devoted to machine tools of different kinds, including two planing machines with beds 2 ft. wide by 6 ft. stroke, and a shaping machine, made by Messrs. Hulse & Co.; two wheel lathes of 6 ft. and 7 ft. diameter for turning and boring, made by Messrs. Fairbairn, Naylor & Macpherson; one screw-cutting lathe, two finishers' lathes, one screwing, and one drilling machine by Messrs. Smith & Coventry, and one screw-cutting lathe by Messrs. Sharp, Stewart & Co. Four Bruce-Peebles 4-pole shunt-wound motors of 8 h.p., running at 820 revs. per minute, serve to drive this set of tools, current being taken from the 460-volt circuit, and each motor is controlled by a Cutler-Hammer starting rheostat, with automatic release and overload preventer, made by the Sturtevant Engineering Co. One motor is used for driving a line of shafting, by which power is transmitted through belts and countershafts to the two planing machines and a large grindstone. Each of the wheel lathes is driven by a separate motor acting through a countershaft fitted with the usual cone pulleys; and the remainder of the tools are driven from countershafts in connection with a line of shafting operated by another motor.

A feature of great interest at the Slade's Green establishment is the electrically-driven coal-conveyor. It is used for drawing coal from the store adjacent to the locomotive shed, and to deliver it into the coal bunkers of tenders which are drawn for the purpose beneath the delivery

shoot of the conveyor. The apparatus was specially designed by Messrs. Kirkland & Capper, and manufactured by Messrs. Waygood & Co., to comply with the condition that it should be capable of delivering coal into the tender of a locomotive as fast as four men could shovel it out of trucks into the hopper of the elevator. By Fig. 10, it will be seen that the design is that of a bucket elevator driven through belting by an overhead motor. There is an extremely ingenious device consisting of an automatically locking starting switch, which prevents the motor from being started when the hopper door is open. It is therefore impossible for coal to be discharged except when the motor is running at full speed, a point of some importance. Coal is delivered into the coal bunkers of the tender through a shoot fitted with a water spray, so as to precipitate dust. The delivery shoot is movable through a considerable arc, so that the coal may be distributed evenly from end to end of the tender, thereby avoiding trimming as far as possible. As the requirements of the station develop, it is proposed to fit a travelling hopper, so that with two or more elevators, the process of discharging from the coal trucks may be kept continuously going, concurrently with the work of loading into the tenders. It will readily be realised from the above description that the arrangement is of entirely novel character, and we are pleased to be able to state that the railway officials are in every way satisfied with its performance of the duty required.

The South Eastern and Chatham Railway Company are to be congratulated on the important and thoroughly modern plant which has formed the subject of this notice. The installation, which is under the care of Mr. Bayley, as engineer-in-charge, certainly reflects credit upon the enterprise of the Company, as well as upon the engineers who have designed and brought the work to a successful issue.

In conclusion, we have to acknowledge the courtesy of Mr. Vincent Hill, the General Manager, Mr. Leonard, the Eletrical Engineer, and Mr. Warrington, the Locomotive Superintendent, and other officials, in affording facilities for taking photographs and other particulars necessary for the purposes of this article.



High-Speed Engines.

By J. H. DALES, A.M.INST.C.E.

Continued from page 26.

AFTER dealing with the difficulties of providing for the effects of inertia, the next point of importance is the demonstration of its value. Without inertia and momentum the reciprocating engine would be impracticable for almost any purpose, but more especially where the conversion of linear to rotary motion is concerned. One of the most remarkable features of the reciprocating engine is the close approximation to an uniform torque which can be obtained from it by suitable combinations of steam pressure or piston area, weight of reciprocating parts and speed. Possibly the most remarkable point is, that the best turning at high rates of rotation can be converted from a reciprocating piston on which a comparatively high grade of expansion is used, in fact, that the best turning cannot be got in such circumstances from a very late cut-off. It is one of the many happy and remarkable features of the steam engine, in itself the most remarkable machine ever invented, that it is at its best as a motor when working with a high grade of economy; not the highest grade possibly, but not very far from that desideratum.

But a steam-engine, above all things, must be designed with an intelligent appreciation of the physical properties of the vapour of water and heat, as well as those of the metals and materials of which its mechanism is composed; of the statical and dynamical properties of matter; and of the geometry of its motions. Added to these, an embodiment with the best kinds of mechanical workmanship, and we have a production which undoubtedly stands at the head of the mechanical art.

Most steam engineers have in their early days had a try at the invention of a true rotary engine, and it is only when they have exhausted their resources of knowledge and ingenuity, that they realise that no rotary engine can be made to give the results of a well-designed reciprocating engine, and that, setting aside the matter of cost, which is all in favour of the latter, a direct rotary motion is impracticable, inasmuch as, having no reciprocating parts, it cannot fully realise the benefits of steam used expansively. Flywheels connot accomplish the same ends as reciprocating parts. It is necessary to fully realise this.

It yet remains to be shown whether steam turbines can justify any claim to the efficiency of the reciprocating engine in either a general or particular sense.

But it would be travelling beyond the province of these articles to make any attempt at dealing with the whole philosophy of the steam-engine, the consideration of the mechanical construction and action of the reciprocating engine at high rates of rotation being their sole object.

As the design of a steam-engine is the working out of a very complex problem, the factors must first be laid down, some obtained from philosophical reasoning, and some from empirical rules and data. The point at issue for the moment is the proper utilisation of the inertia of the reciprocating parts by producing a balance or suitable resistance to the initial steam pressure; and afterwards, when the steam pressure diminishes by reason of expansion, to maintain a sufficient pressure on the crank-pin by means of the momentum of the piston line, thus to convert a very variable force on the piston into a comparatively uniform force on the crank-pin.

As all calculations of this class are only approximate, much time and labour may be saved by consulting worked-out results of various kinds, by means of which a near judgment may be formed of how and where to begin with the solution of the problem.

In the matter in hand it is useful to know what is the most economical cut-off for any given pressure, and at the same time the relative economic value of the same. For this purpose Table I. has been made. It contains the calculated approximate results of steam worked expansively, non-condensing, at various pressures from 40 lbs. absolute to 180 lbs. absolute, allowing for a back pressure of 14·7 lbs. For other back pressures corrections per lb. over 14·7 may be made by deducting the co-efficients of economy at the foot of each column. The table is constructed by working out the mean pressures absolute of a saturation curve, at cut-offs from ·01 to ·70 and deducting the back pressure, dividing the result by the cut-off ratios in the case of 40 lbs., and in those of higher pressures by again dividing by the ratios of their specific volumes to that of 40 lbs.; thus producing a series of weight for weight co-efficients of economy.

In trial designs, after working out desirable combinations of inertia and pressure diagrams, a near judgment of their economic values may be made by a simple inspection of the table. It will be seen that there are considerable ranges of cut-off in which the economy varies very little, say under 2 per cent., but that immediately outside these there is a rapid diminution in both directions, so that while there is ample governing range for a good design or suitable combination, there is no room for guess-work. As a matter of fact, the relative size of engine to work has the principal influence in economical working or otherwise. But, for the moment, the matter of torque is the main concern. The fact that the steam-engine, as well as every other motive power, is invariably the means to an end, and not the end, should never be lost sight of, and that the true end of such power is the production of the largest amount of useful work in effect for the smallest collective cost. Another point to be kept in view is that the coal bill is by no means the largest item in the cost of production of any power-manufactured commodity, and that attempts at extreme economy in fuel alone may easily lead to a loss in a general sense. Hence, if the best possible quality of driving can only be obtained by arrangements which are not strictly the most economical in steam, they may still be by far the most profitable.

An illustration of this may be made by considering that the coal bill of an average mill, say a cloth mill or factory, is only about $2\frac{1}{2}$ per cent. of the wage item, and that good design and adaptation in an engine will make it possible to run or govern to within 1 per cent. of the highest speed or rate of production which the material operated upon will admit of, while an average rule-of-thumb design would not govern to nearer than 7 per cent.—many to nearer 10 per cent. It requires no great penetration to see that, while good running and governing produces $99\frac{1}{2}$ average per cent. of the possible, with a 7 per cent. variation, the production would be only $96\frac{1}{2}$ per cent. of the possible, or 3 per cent. less work for all the same general costs, or a loss of more than the value of the whole of the coal bill. This is a commercial view, which is, after all, the only crucial test of the value of mechanical arrangements.

If the case of an electric generating station, where the coal bill is a relatively larger item, be considered, the same line of reasoning still holds good. The item in question is about 17—28 per cent. of the cost of production of the current—not considering the capital outlay entailed in distribution—but only 5—9 per cent. when that is included, while the cloth-mill cost is in such connection only about $1\frac{1}{4}$ per cent. of the total costs.

If anything, good running is of more importance in the electrical business than in the other case quoted, as the greatest loss of production occurs when the heaviest loads are on, and so forms a larger proportion; and a close approximation to the "possible" turn-out of work will save more than the whole of the coal bill even in this case.

There can be no question that uniformity of torque is of primary importance in steam-engine work; as without it no first-class governing can be had, and without first-class governing both quantity and quality of production must suffer. There-

TABLE of Values of equal Weights of Steam at different cut off or ratios of Expansion and at different Pressures. Non-Condensing. 14·7 lbs. allowed for back pressure.

Cut off.	Pressures per square inch absolute.							
	40 lbs.	60 lbs.	80 lbs.	100 lbs.	120 lbs.	140 lbs.	160 lbs.	180 lbs.
	1	2	3	4	5	6	7	8
·010	.....	.....	.....	.....	.....	.....	.....	.....
·015	.....	.....	.....	.....	.....	.....	.....	.....
·020	.....	.....	.....	.....	.....	.....	.....	·0020
·025	.....	.....	.....	.....	.....	.....	.....	·050
·030	.....	.....	.....	.....	·0035	·029	·048	·063
·035	.....	.....	.....	.....	·025	·046	·063	·077
·040	.....	.....	.....	·016	·042	·061	·076	·087
·045	.....	.....	.....	·026	·050	·067	·080	·090
·050	.....	.....	.....	·036	·057	·073	·085	·094
·055	.....	.....	·016	·038	·064	·078	·090	·098
·060	.....	.....	·024	·052	·068	·081	·093	·100
·065	.....	.....	·031	·055	·072	·084	·094	·101
·070	.....	.....	·036	·060	·074	·086	·095	·102
·075	.....	.....	·041	·063	·077	·088	·096	·103
·080	.....	.....	·045	·065	·078	·089	·097	·103
·085	.....	.....	·047	·067	·079	·089	·097	·103*
·090	.....	.....	·050	·068	·080	·089	·098	·103
·095	.....	.....	·052	·069	·081	·090	·098	·102
·100	.....	.....	·053	·072	·082	·090	·098*	·102
·105	.....	.....	·057	·073	·083	·091	·098*	·102
·110	.....	·035	·0595	·074	·084	·0915	·098	·102
·115	.....	·037	·061	·075	·084	·0920	·098	·102
·120	.....	·039	·062	·076	·084	·0920	·098	·101
·124	·001	·041	·062	·076	·085	·0920*	·097	·101
·130	·004	·043	·063	·077	·085	·092	·097	·101
·135	·007	·045	·063	·077	·085	·092	·097	·100
·140	·010	·046	·064	·077	·085	·091	·096	·100
·145	·012	·047	·065	·077	·085	·091	·096	·099
·150	·014	·048	·065	·077	·085*	·090	·096	·098
·155	·016	·049	·065	·077	·085	·090	·096	·097
·160	·018	·050	·065	·077	·085	·090	·096	
·165	·019	·050	·066	·077	·084	·090	·096	
·170	·021	·050	·067	·077	·084	·089	·096	
·175	·022	·051	·067	·077*	·084	·089		
·180	·024	·052	·067	·077	·083	·089		
·185	·025	·053	·067	·076	·083	·088		
·190	·026	·053	·067	·076	·083	·088		
·195	·027	·053	·067	·076	·082	·087		
·200	·028	·054	·067	·076	·082			
·205	·029	·054	·067	·076	·082			
·210	·030	·054	·067*	·076	·081			
·215	·031	·055	·067	·076	·081			
·220	·031	·055	·067	·075				
·225	·032	·055	·067	·075				
·230	·032	·055	·067	·075				
·235	·033	·055	·067					
·240	·034	·055	·066					
·245	·034	·055	·066					
·250	·034	·055	·066					
·255	·035	·055	·066					
·260	·035	·055	·066					
·265	·036	·056*	·066					
·270	·036	·055	·066					
·275	·036	·055	·066					
·280	·037	·055						
·285	·037	·055						
·290	·037	·055						
·295	·037	·055						
·300	·037	·055						
·305	·037	·055						
·310	·037	·055						
·315	·0370	·055						
·320	·0380	·055						
·325	·0380	·055						
·330	·0380	·055						
·335	·0380	·054						
·340	·038	·054						
·345	·038	·054						
·350	·039	·054						
·355	·039	·054						
·360	·039	·054						
·365	·039	·054						
·370	·039	·053						
·375	·039*	·053						
·400	·039	·053						
·450	·038	·050						
·500	·038	·049						
·550	·037	·047						
·600	·036	·045						
·650	·034	·043						
·700	·033	·041						
Deductions from values (highest) per 1 lb. back pressure over 14·7.								
	·00243	·00257	·00269	·00279	·00287	·00294	·00300	·00305

fore if uniform torque costs more in steam than bad turning, work for work indicated, the good turning may still be much the cheaper.

Coming to the consideration of how this desirable uniformity of torque may be obtained, one of the most difficult, or rather abstruse, problems in steam engine design has to be faced. It is notorious that some engines "run" very much better than others, for reasons which are not always clear on the surface, but which really arise out of combinations which, perhaps, may be said to be accidental, and it is for the purpose of clearing up some of the causes of such "accidents" that the following considerations are entered upon. The speed and power of an engine are usually fixed by the requirements of its uses, and it remains for the designer to make such combinations of weight in the piston line, length of stroke, and piston pressure (not necessarily steam pressure) as will give the best results in uniform turning and quiet action. The minimum weight of the piston line (which in this connection includes the connecting-rod) arises out of the necessary strength which must be provided for the power required, and on this point of weight little can be done in the way of alteration except by increasing it; so, as several matters involved depend upon one another, it is usually best to commence the design of an arrangement by taking the minimum weights, something in the way described in a previous article. The next thing to be done is to find the inertia of the piston line to the speed employed, by considering the weight of line as concentrated at the crank centre, and computing the centrifugal force of the same. Then, having drawn a base line of a steam diagram to be constructed, raise perpendiculars ($a\ a^1$, Fig. 1) to the points corresponding to the two dead centres of the piston stroke, and of a length which represents such centrifugal force to scale, as a pressure per square inch on the piston area. No consideration at this stage is given to the accelerating and retarding effect of the connecting-rod.

Inertia would, of course, disappear at a point in the stroke at which the speed of the piston line attained a maximum, which, when no account is taken of the connecting-rod, or that is reckoned of infinite length, would be midway between the extremities of the stroke. The diagonal which is drawn through this point, joining the centrifugal force perpendiculars, forms two triangles, which, by their areas, represent the inertia and momentum of the piston line as minus and plus quantities in whichever direction the stroke is taken; and as this inertia and momentum are equal, so must be the triangles. If steam-engine diagrams be constructed to cover these triangles, and the initial pressure be made to correspond with or to be greater than the height of their perpendiculars to the base line, it is clear that there would always be a positive pressure on the crank-pin, and that whatever portion of the steam diagram is absorbed by that of the inertia in the fore part of either stroke, the same amount of force would be applied to the crank-pin by the momentum diagram in the latter part of the stroke, and so in a measure equalise throughout the stroke that varying force which would otherwise arise from steam used with a comparatively high grade of expansion. So far so good, and on this line of reasoning, with similar steam diagrams, similar torque lines would accrue for both "out" and "in" strokes. As, however, a "finite" length of connecting-rod has to be used, and as that "finite" makes a considerable difference which largely upsets the foregoing conclusions, it is necessary to make some important corrections which materially complicate the problem. The connecting-rod not only accelerates the piston motion in the first half of the "out" stroke, and retards the same in the latter half with a reverse action on the "in" stroke, but has a motion of its own, which varies between the circular motion of the crank-pin and the linear motion of the cross-head; and added to the more abstruse consideration of these features is that of the distribution of the weights of the connecting-rod, which makes any attempt at an exact determination an unprofitable labour, unless applied to an individual case. A sufficiently close approximation

to the truth, however, for practical purposes, is not difficult to arrive at, when rods of ordinary length—say 4 to 6 crank lengths—are under consideration. The total weights concerned are taken as being in the piston line proper. If a proportion of the length of the centrifugal force ordinate (ascertained as before stated) at the point of commencement of the "out" stroke, equal to that of the crank length to the connecting-rod length, be *added* to that ordinate, and a like proportion *subtracted* from the centrifugal force ordinate at the other end of the same stroke, two points are obtained between which and through a point in the steam diagram base line corresponding with the maximum speed of the piston (connecting-rod taken into account) a curve may be drawn, which includes two areas closely representing the actual results of the combined inertia effects of the connecting-rod, and the other parts of the piston line. These areas must, of course, be equal; and if the steam diagrams are similar, the work performed on both strokes would also be equal. But the forms of the torque diagrams obtained with these corrections are by no means alike at corresponding points in the "out" and "in" strokes. Referring to Figs. 1 and 2, the former shows the centrifugal force line (*a a'*), the corrected inertia line (*b*), and the pressure lines (*c c c*) of three different "cut-offs" of a steam diagram. The vertical lines (*d d d d, d' d' d' d'*) corresponding with crank positions represent the actual combined steam and inertia pressures on the crank-pin, and, resolved into the tangential direction of the crank path at the points shown, and set off radially outside the crank path, they give a graphic representation of the resulting torque at the different points in a revolution. The boundary curve encloses all other radials. The same inertia line serves for both upper and lower steam diagrams, being, as shown, greater at the commencement and less at the end of the "out" stroke, and less at the commencement and greater at the end of the "in" stroke, which makes a material difference in the torque diagram to what would be the result if only the straight centrifugal force line is taken into consideration.

Three different "cut-offs" are shown, in order that the result of "cut-off" may be readily seen by the torque lines, and how an adjustment of the "cut-off" may be made for producing uniformity in the turning force. The necessary compression for filling the clearances brings down the steam and inertia areas at the exhaust end of the strokes, and favourably affects the shape of the torque diagrams.

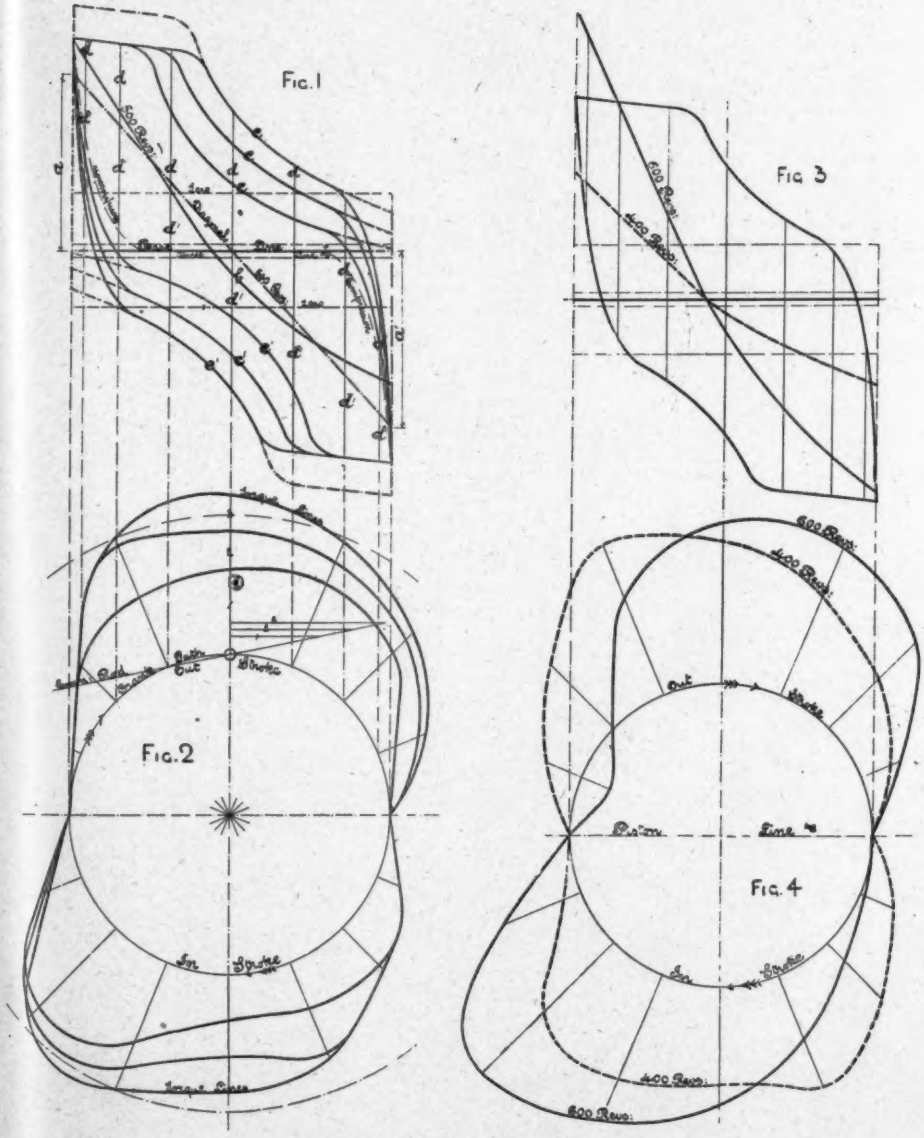
The best results of quiet running are obtained where there is a balance at the commencement of the stroke between the inertia of the reciprocating parts, plus the engine friction, and the steam or piston pressure. The dotted line above the full steam diagram shows 10 lbs. to the scale as a provision for the engine friction and for ensuring an always positive force on the crank-pin, on the dead centre of the piston motion. The torque line rises out of the dead centre in such case, at or near a tangent to the crank path. In no case should there be any negative action of the piston line on the crank-pin *after* the commencement of a stroke, as that would lead to a disagreeable double knock on both ends of the rod, which no engine-house management could eliminate.

High-speed engines, more than any other, require a careful arrangement of the weights and forces referred to, on account of their much greater inertia, than long-stroke engines, but a successful combination produces results which cannot be obtained by the use of the slow type, nor by any other means. Truly wonderful running, and a high degree of economy at the same time, can be obtained from a good design.

In Figs. 1 and 2 the diagrams are constructed for an engine with a piston line weighing 250 lbs., stroke of 8 ins., and a speed of 500 revolutions. The initial pressure of steam is 90 lbs. absolute on a piston area of 134 ins.

Figs. 3 and 4 show the effect of different speeds, these corresponding to 400 and 600 revolutions, with the same particulars as Figs. 1 and 2.

Lowering the speed to 400 revolutions causes an excess of pressure on the crank-



HIGH-SPEED ENGINES: FIGS. 1, 2, 3, AND 4.

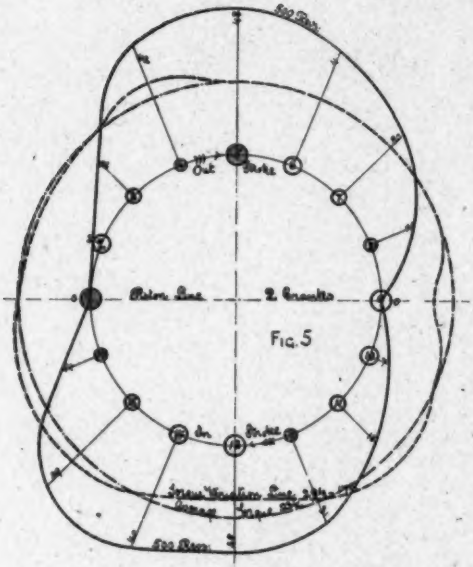


Fig. 5

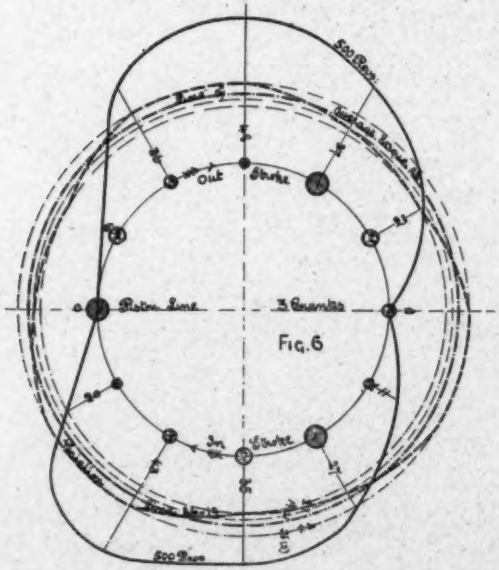


Fig. 6

HIGH-SPEED ENGINES: FIGS. 5 AND 6.

pin in the early part of the stroke, with too little in the latter, from dropping the inertia curve; while raising the speed to 600 revolutions produces a negative effect on the crank-pin in the early part of the stroke and an excess of pressure in the latter.

The torque radials in Fig. 2 occupy about $\frac{3}{5}$ of the annular space, which is enclosed by a circle just covering their maximum extensions, and an approximate guide to the construction of a steam diagram which will give the desired power may be made by drawing such a circle completely round the crank path as would give a torque radial of $\frac{5}{7}$, the average length required for the service desired; that is to say, that if the travel of the crank-pin, taken for power, be divided into the foot-pounds of work required and again by the cylinder area, the result to scale would give a length of radial which, multiplied by $\frac{5}{3}$, would be the maximum radial required for the construction circle referred to. The "half-stroke" radials of the construction circle would give the steam pressures at that point which the constructed diagram should have for providing the required power. Other radials, which would correspond with an uniform torque for the moment, can be plotted above and below the inertia curve for an approximation to a steam diagram, which must be selected and adjusted to give the best average result.

It is clear from the diagram that no perfectly uniform torque can be obtained, even by the most careful arrangement, the figure showing about as good a result as can be had, but it is equally clear that very bad results might accrue from neglect of proper investigation.

The practical draughtsman with a correct appreciation of principles will find no great difficulty in arriving at a conclusion as to what his design is likely to produce. Single-cylinder engines (double-acting) with very light fly-wheels (as light, in fact, as they can be made from pressed plate) and shaft governors, when suitably designed on the lines indicated, will run 600 revolutions per minute (6-in. stroke) in a very perfect and remarkable manner. The maximum acceleration when getting up speed with full steam on the piston, in such an engine, is about 2 per cent. per stroke, while on full work it is much under 1 per cent. per stroke; and governing from full load to no load with about 1 per cent. total variation of speed is quite practicable.

Seeing that very uniform running can be obtained from single-cylinder high-speed engines if they are well designed and adapted, it becomes doubtful whether the increased cylinder losses, friction, cost, attention, and other drawbacks of a multiplicity of cylinders is justified, in most cases, by results. One thing is certain, that well designed, well governed single engines, running at high speeds, give results which are so very good, as regards steady turning, that it is extremely difficult to make an instrument which will show any difference of betterment, and it does not appear that, except by compounding for purposes of economy, any distinct advantages can be obtained by a multiplication of sets of cylinders in one engine. Of course, "well designed and well governed" is a necessary saving clause in this connection.

The up-stroke in a vertical cylinder engine should be arranged with a slightly later cut-off than the down-stroke, to compensate for the gravity of the piston line. In the example dealt with in the diagrams the piston line weights amount to about 2 lbs. per sq. in. of piston area, which, being plus and minus, is a difference of 4 lbs. per sq. in. average pressure in the steam diagrams, which quantity, amounting to from $\frac{1}{6}$ to $\frac{1}{15}$ of an average pressure, is important. Also this is a separate item not included in the inertia effects.

Of the various kinds of "knock" in a steam engine that of the connecting-rod of the piston line is usually the most difficult to deal with successfully. With ordinary arrangements close-up adjustment of the bearings is inadmissible, for the chief reason that it leaves no room for the expansion of the parts as their temperature rises by reason of their unavoidable friction, however little that may be. Nothing is nothing, and as next to nothing, in the ordinary acceptation, is sufficient to cause a knock, the difference between an adjustment which will run

with a very slight knock, and which may "seize," and the heaviest knock admissible is so very little that even the most careful attention cannot insure safety. As little as $\frac{1}{500}$ of an inch clearance can be heard if the inertia and pressure do not balance pretty nearly, and if there is either any great preponderance of pressure over inertia or any negative effect of inertia $\frac{1}{100}$ of an inch will cause a very heavy—in fact, quite inadmissible—knock. At the same time it may be noted that a 4-in. neck and brasses will expand between 60 degs. and 300 degs., about $\frac{1}{100}$ in., so the puzzle is what to do to avoid trouble; and it is plain that as clearance is ordinarily necessary, a proper adjustment of inertia and pressure is the only way of securing safe and quiet running. Compression, of course, will do something, but it is not generally dependable, nor, for many reasons, can it always be had to a sufficient extent.

Long-stroke horizontal engines having the air-pump worked off the tail end of the piston-rod are particularly liable to knock caused by excessive inertia, which is very troublesome. A 5-ft. stroke 30-in. single cylinder engine of this class requires at 50 revolutions (500 ft. per min.) an initial steam pressure of 80 lbs. for quiet running. Less than this results in a knock as stated, which no engine-room management or care can cure, and as the inertia increases as the square of the speed, 60 revolutions (600 ft per min.) would require $\frac{36}{25}$ of 80 lbs., or about 113 lbs. Or if such an engine is required to run on 80 lbs. steam at 60 revolutions, the cylinder would have to be increased in diameter in direct proportion to the speed, as the area increases as the square of the diameter, and 36-in. diameter would meet the case.

Fig. 5 is a combined torque diagram of a pair of engines, with cranks at right angles. This diagram is perhaps simpler than that ordinarily used to show combined turning results. It is made by setting out a torque diagram of one piston line (as in Fig. 1), but with two points (cranks) in the crank path, which are followed in couples as they stand at the points marked round the circle. It is evident that the combined torque at No. 1 will be the average of the force radials $\frac{0+48}{2} = 24$. At Nos. 2 and 6 (corresponding positions) there will be $\frac{3+41}{2} = 22$, and so on, which, to scale, set off on radials corresponding with points 1, 2, 3, 4, etc., mark limitations in a curve which represents the turning force on the crank-pin at the 1, 2, 3, 4, etc., positions of the "following" crank. The sum of the radials divided by their number of course gives the average torque radial and circle. It will be seen that the crank-pin effort of this combination varies from 28 to $17\frac{1}{2}$. The average radial is 23. The extreme variation is nearly 36 per cent., but some of the variations are through only a small portion of the revolution. Fig. 6 shows a three-crank combination, constructed in a similar manner to Fig. 5. The variation in this case is 26 to 19—about 27 per cent.

Both these diagrams show, by the scale length of the radials to the numbers, the combined torque in pounds pressure per square inch of the combined areas of the cylinders, so that whatever the cylinder areas may be in the aggregate, that quantity multiplied by the radial at any set of points would give the torque at that instant. All the figures are constructed from the indicator diagram in Fig. 1. In Fig. 5 the numbered points make a complete revolution, but in Fig. 6 only go through 120 degs., as there is a repetition of combinations through each 120 degs. section of the revolution.

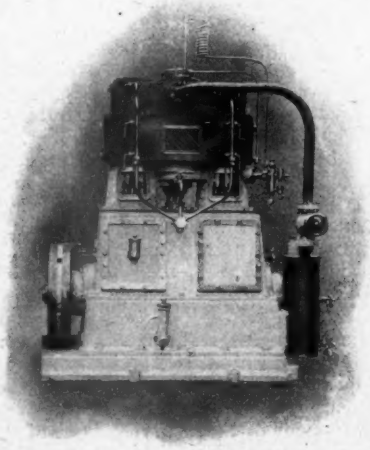
A little careful study of the foregoing matters clearly shows that there is a necessary close relationship between pressures, weights, and speeds, which cannot be violated with impunity. No really good, free, unlaboured running can be had from reciprocating engines without proper attention is paid to the proportions of these items. One striking feature is, that only very moderate pressures are required for very high speeds, but that the pressure has to be such as will give the required "form" of steam diagram: the piston pressure has to be made up by piston area. Another feature is, that in order

to get steam economy, and a sufficient grade of expansion for the purpose, the weights must be made for the pressures in the case of low speeds. A low rate of speed (revolution) must have a heavy piston line, while a high rate of speed must have a lighter one. The high-speed piston line will therefore be designed exactly proportionate for strength, but the slow-speed piston line must be loaded by weight over and above what is necessary for strength; probably the best and most convenient part for loading is the piston head or block.

It is clear that no fixed proportions of piston diameter to stroke can be made use of if the best results are required. Every speed requires special design. Compound combinations are probably the most difficult problems which have to be dealt with in this connection, as so very many more points have to be considered than in single-expansion engines. In a future article these will be shown.

H. A. Dales

(To be continued.)



The Evaporation of Liquors.

By A. E. JORDAN.

A GREAT deal of attention has been given during the past few years to the apparatus used for the evaporation of different kinds of liquors; and engineers at home and abroad have been at their wits' end to design an apparatus that could be adapted for every kind of liquor required to undergo this most important and necessary process. Various patents have been taken out, and numerous evaporators have been tried in various industries, but for the most part have been far from satisfactory, being either too complicated to work, too wasteful in the consumption of fuel, or on account of their falling far short of the guaranteed duty; and for these reasons alone there are at present innumerable factories carrying out this important process of evaporation in the old, primitive way of boiling the liquor in open vessels under atmospheric pressure by the aid of a fire underneath.

The evaporators boiling the liquor in the open consist principally of hemispherical vessels, and which are used either singly or in battery; in the latter case the liquor undergoing a certain amount of boiling in each, and ladled by hand from vessel to vessel until the liquor is brought to the required density in the last vessel of the battery. The vessels are built on brick setting, and arranged in such a manner that the gases from the furnace under the last vessel of the battery are conveyed along and under each of the vessels on their way to the chimney, the greatest heat thus coming in contact with the vessel containing the thickest liquor.

Fig. 1 shows an illustration of a battery of those vessels as at use in many of the industries. It is a slow and expensive method of carrying out the evaporation of the liquor, as well as dangerous, as in many instances factories have been completely destroyed by fire due to the liquor in those open vessels becoming ignited.

Another form of an open evaporator is "Fryer's" Concretor, which is shown illustrated in Fig. 2, and consists of a series of trays over a fire, similar to the vessels previously described, a revolving cylinder and an air-heater, the method of working being as follows:—The liquor is run on to the tray at the end over the furnace, and by means of divisions in the tray, which is placed on a slope, the liquor travels in a zig-zag fashion, and at the same time slowly gravitates to the other end of the tray, from whence it is taken by the pump and delivered into the revolving cylinder. On entering the revolving cylinder the liquor is conveyed to the opposite end by means of spiral plates coming in contact on its way with a current of hot air from the air-heater, and which is drawn through by a fan running at end of the revolving cylinder. The trays are a continual source of annoyance on account of their getting burnt out and cracking over the furnace, and of the continual attention which the apparatus requires, let alone the most important objections, which are its lack of economy and cleanliness.

A more improved apparatus for evaporating liquor in the open is that of the Wetzel Pan, which may also be worked singly or in battery, exhaust steam being used as the heating agent in this case. This apparatus consists of a trough for containing the liquor to be evaporated and a revolving barrel, or nest of tubes, the method of working being as follows:—The liquor is run into the trough and the revolving tubes, to the inside of which exhaust steam is admitted at one end, raise a thin layer of the liquor on each, which is rapidly evaporated by the heat of the steam inside the tubes. The condensed steam is run off through a steam trap. The heating tubes in the Wetzel Pan are often arranged horizontally, and also in the form of a coil. The illustration, Fig. 3, however, shows an

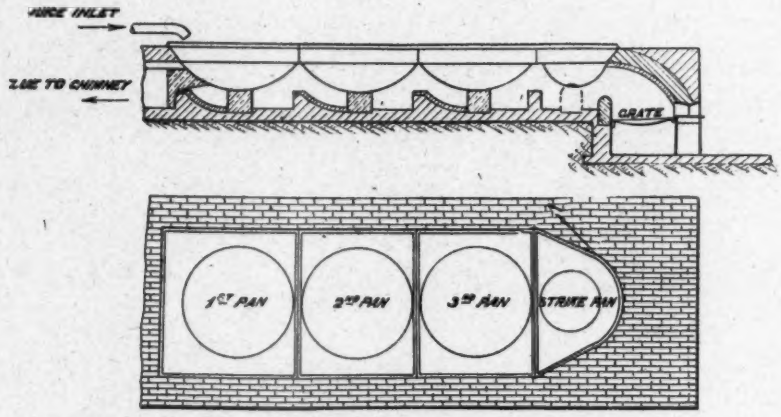


FIG. 1.—BATTERY OF OPEN EVAPORATING PANS.

improved method by Messrs. Fullerton, Hodgart & Barclay, Ltd., Paisley, N.B., in which the tubes are arranged obliquely, thus obtaining greater efficiency on account of the liquor running lengthwise down the tubes, and insuring its being evaporated, instead of its dropping back into the trough before the heat has had time to get at it.

Where the output of the factory is larger, and economy in working and satisfactory profits are to be obtained, the evaporation is now carried out on the Multiple-Effect system, which consists in the utilisation of the latent heat of the vapour from the liquor undergoing boiling under a certain pressure to effect a further evaporation upon the same, or some other liquor in another vessel under a lower pressure, and consequently at a lower temperature.

To carry out the evaporation on this system, and with all kinds of liquors, an evaporator has been designed and

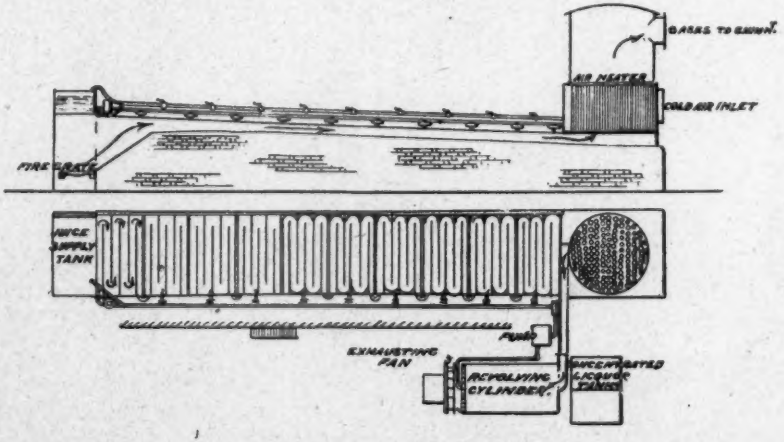


FIG. 2.—FRYER'S CONCRETOR FOR OPEN EVAPORATION.

patented by Mr. James Foster, M.I.M.E., the well-known authority on evaporation, and author of "The Treatise on Evaporation by the Multiple-Effect System," this apparatus being made at the works of Messrs. Fullerton, Hodgart, and Barclay, Ltd.

This evaporator may be made in either single, double, triple, or quadruple effect, according to the requirements of the case; and is an improvement on the many types of ordinary vertical evaporators made at present by many engineers for the sugar industry. Among the many improvements which it possesses may be mentioned better circulation of the liquor and

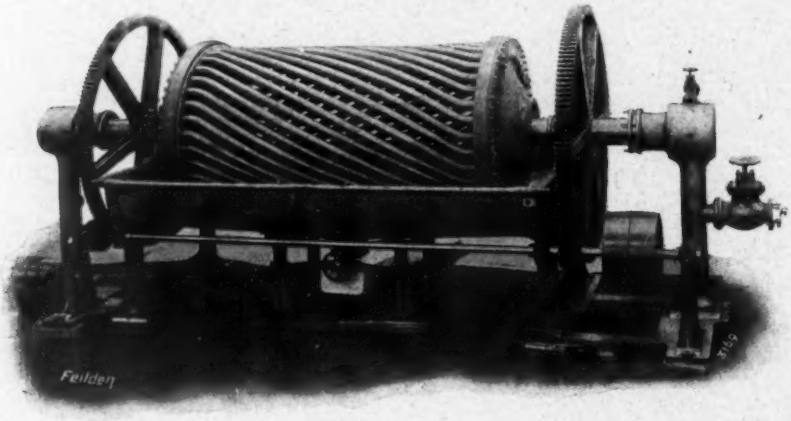


FIG. 3.—METHOD OF OPEN EVAPORATION WITH OBLIQUE TUBES.

the steam, freer outlet for vapour, better method of withdrawing condensed steam, etc. It is in suchlike details, which are entirely overlooked by many makers, that the efficiency and successful working of an evaporator to a considerable extent depends.

Where the liquors that are treated deposit salts during evaporation, Mr. Foster attaches to his apparatus an arrangement which allows of the salts being precipitated, dried, and withdrawn without interfering in any way with the continual working of the evaporator. The method previously in use, and still in existence in factories where this evaporator is not in use, is to discharge the precipitated salts from the bottom of the evaporator vessels into separate tanks, from which it is carried to the centrifugals, which, of course, require a separate engine, and spun in the same way as sugar is treated in sugar factories.

Mr. Foster's arrangement does away entirely with the centrifugal, having recourse to the simple method of drying the salt by maintaining a vacuum in the drying apparatus, or salt filter, which is attached directly to the bottom of the evaporator vessel. The salt, on being precipitated, is seen to rise in the salt hopper by means of the sight glass for that purpose, when it is allowed to fall into the drying apparatus, or salt filter, by opening the large valve between. This valve is then closed, steam admitted to the salt filter above the salt, while a vacuum is maintained under the salt by means of a pipe connected to the top of the evaporator vessel, through which all liquor contained in the salt is drawn, to mix again with the liquor undergoing boiling. On the salt being dried, the door at the end of salt filter is opened, and the salt raked out into a barrow or truck running on rails. The salt meanwhile is

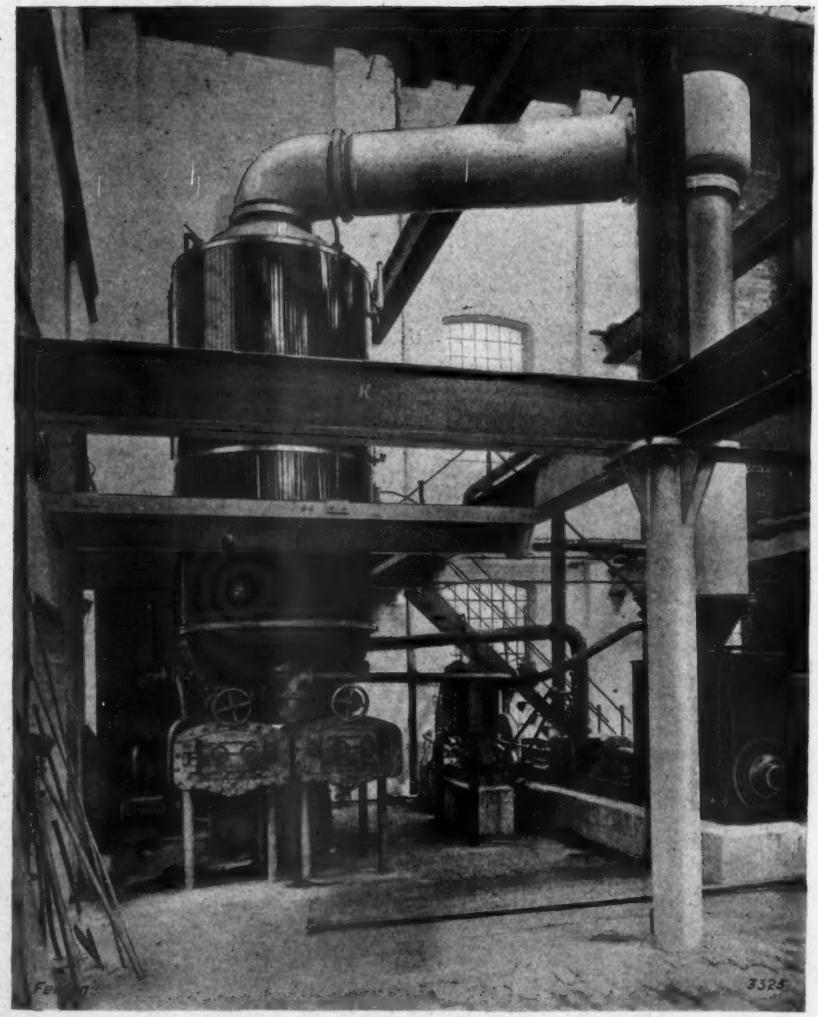


FIG. 4.—EVAPORATING PLANT AT MESSRS. GOODWIN AND SON'S SOAP WORKS, MANCHESTER.

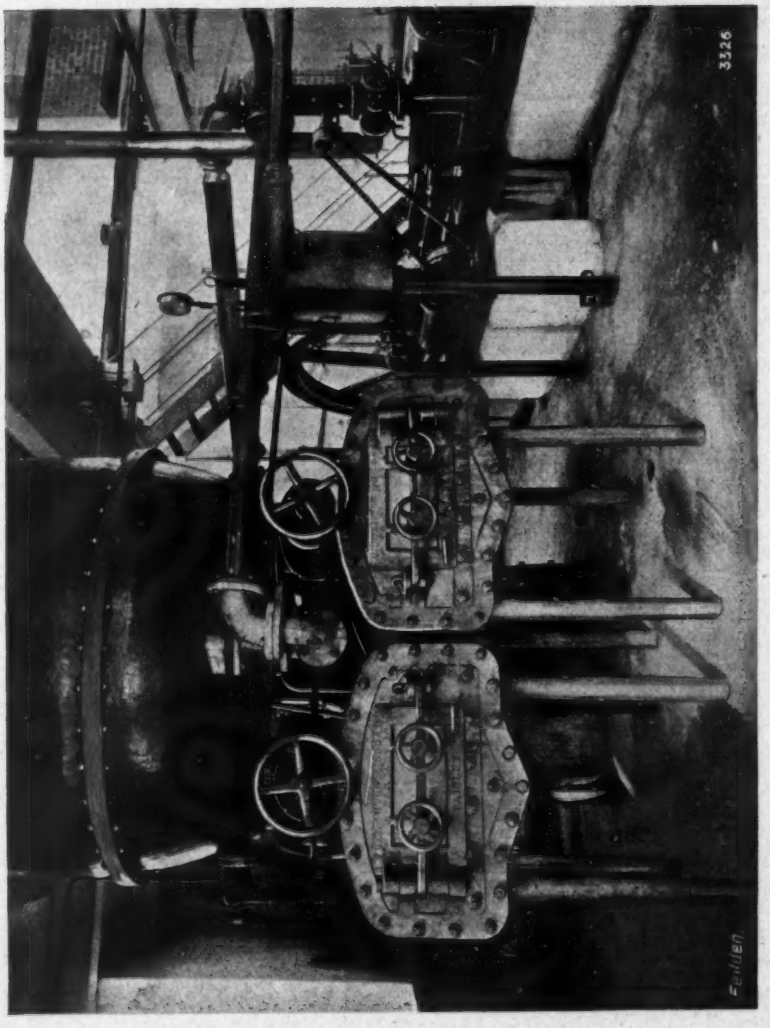


FIG. 5.—SALT FILTERS ATTACHED TO THE PLANT SHOWN IN FIG. 4.

filling up again in the hopper, and on reaching the sight glass the salt filter is again ready to receive another charge.

Figs. 4 and 5 are reproductions from photographs taken of a plant at work in Messrs. Goodwin & Son's Soap Works, Manchester. The illustrations show two salt filters connected to the bottom of the second vessel, this arrangement being most suitable for the larger sizes of evaporators. The hopper is not required in this case, as while the contents of one filter is being dried and raked out, the other is receiving its charge of precipitated salts from the pan, the working being thus carried on continuously.

Fig. 6 shows an illustration of a Foster Patent Double-Effect Evaporator, with the vacuum pumping engine, as supplied to many of the largest soap factories and glycerine manufacturers in this country, on the Continent, and in America, for the recovery of crude glycerine from soapmakers' spent lye, and for the concentration of caustic and the like liquors.

Its advantages are the complete and rapid circulation of the liquor under treatment, which causes rapid evaporation. This has been obtained by distributing the steam and vapour in the most effective manner in the steam chambers of the vessels, and arranging the heating surface so that it takes up all the available heat from the steam or vapour.

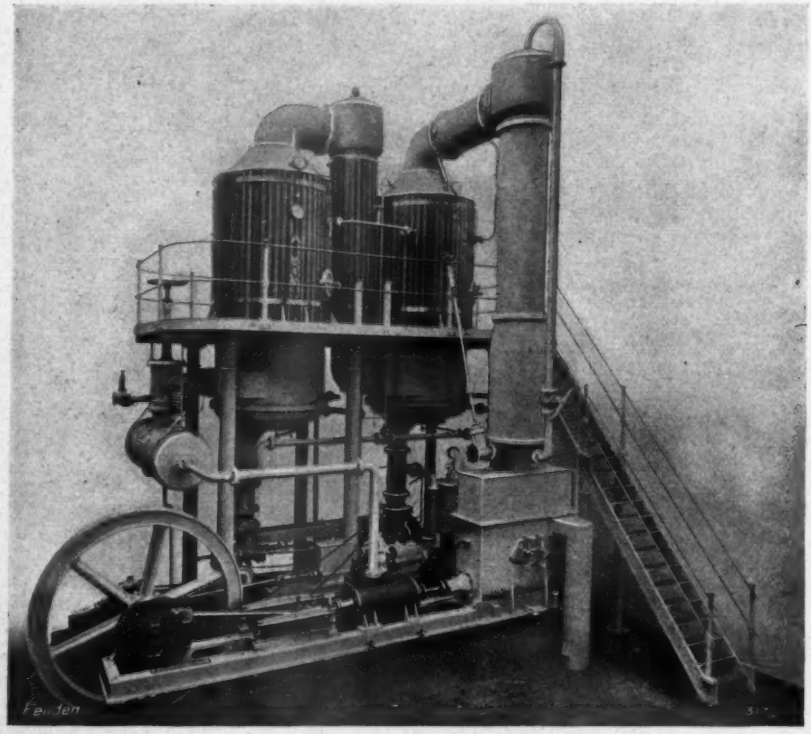


FIG. 6.—A DOUBLE-EFFECT EVAPORATOR.

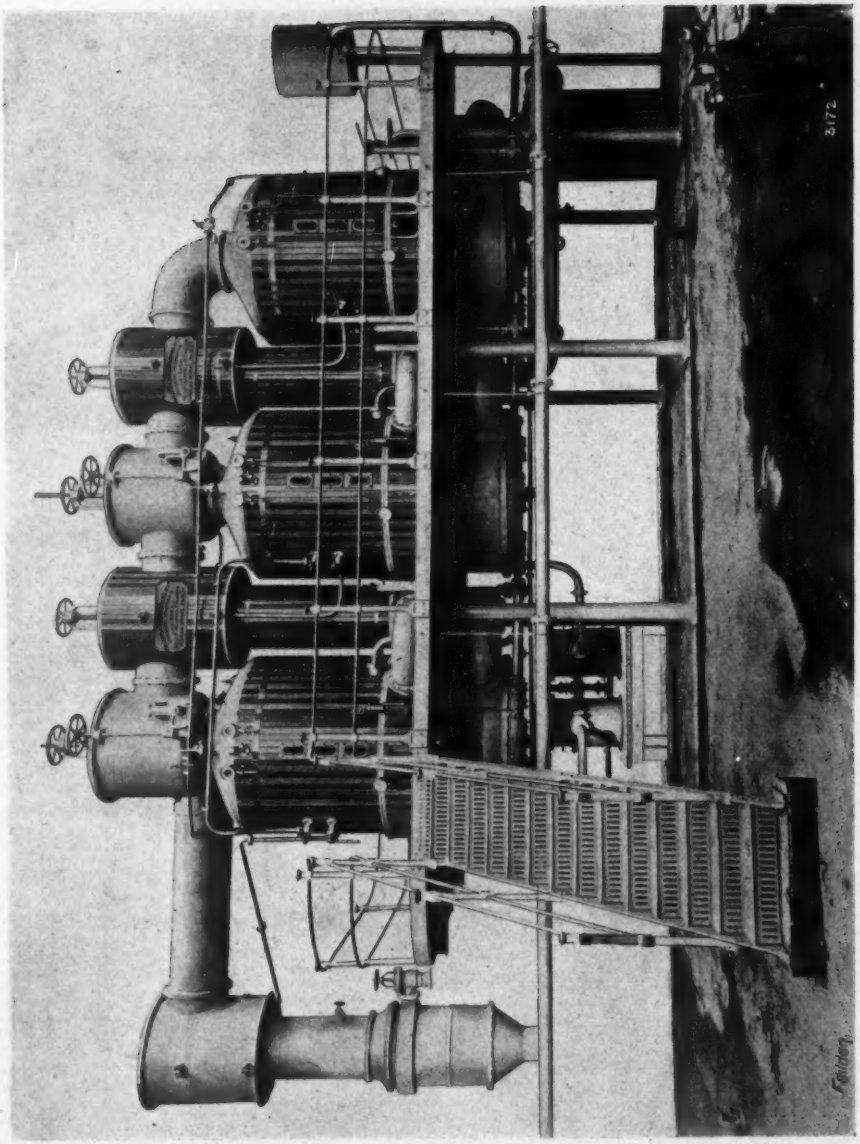


FIG. 7.—A TRIPLE-EFFECT EVAPORATOR AS USED IN THE SUGAR INDUSTRY.

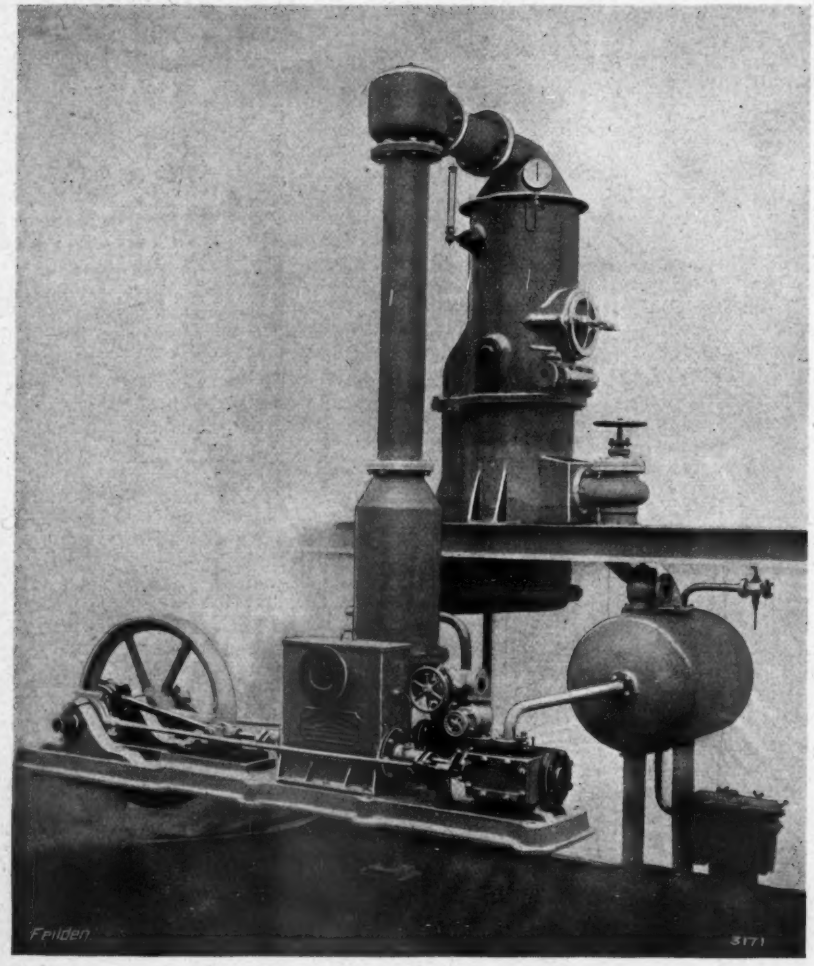


FIG. 8.—PATENT FILM EVAPORATOR

The circulation of the liquor in this apparatus being as near perfect as possible, the salts contained in the liquor have not time to deposit on the heating surface, they being carried to the bottom of the vessel. The bottom of the second vessel of the apparatus is, however, fitted with an improved arrangement for taking the precipitated salts out of the vessel in a dry state without interfering with the continuous working of the apparatus as described above. Only exhaust steam at a pressure of from 3 to 5 lbs. per square inch is required for the evaporation.

In the recovery of crude glycerine by

this type of Evaporator no live steam is required in the second vessel, the batch being finished entirely by the vapour generated from the liquor under evaporation in the first vessel.

The following are particulars of the working of one of these Patent Double-Effect Evaporators, having 600 sq. ft. of heating surface, recovering crude glycerine:—Steam pressure 3 to 5 lbs. per sq. in. in the exhaust steam receiver. Vacuum in the first vessel, 10 to 15 ins., temperature 195 degs. Fahr. Vacuum in the second vessel, 27½ to 28½ ins., temperature 170 degs. Fahr., at which latter temperature the batch is finished, and contains 80 per cent. glycerine, 10 per cent. salts, and 10 per cent. water.

A batch of from 18 to 20 cwt. of crude glycerine is turned out every 12 hours. The cost of producing one ton of crude glycerine by this apparatus is 14*s.* 8*d.*, 26 per cent. more glycerine being recovered than by the open pan process, and the work done in half the time, and a great saving in coal.

Each vessel is fitted complete with front and back sight glasses, thermometers, vacuums, and compound steam and vacuum gauges, air valves, gas and air locks, washout cocks and pipes, large steam stop-valve between the exhaust steam receiver and the first steam chamber of the apparatus, and condensed steam-traps and connections.

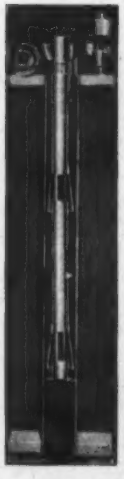


FIG. 9.

The vessels and vapour pipes above the platform are covered with felt lagging, over which polished hard wood is fitted carefully, varnished, and held in place by brass bands.

The apparatus is mounted on a strong platform, consisting of rolled steel girders, supported on cast-iron columns, and fitted with wrought-iron chequered floor-plates, staircase balusters, and polished hand-railing.

The vacuum pump is of an Improved Horizontal Double-acting Displacement Torpedo Plunger type, on top of which is mounted a Cataract Condenser.

Double-Effect Evaporators of a similar design to that illustrated have been made to treat 1000 tons of spent soap lyes or caustic liquor in 140 hours, each of the vessels being 8 ft. 3 ins. diam. inside, and are the largest to be seen in work in the United Kingdom. These evaporators work with exhaust steam only at 5 lbs. pressure per sq. in. in the exhaust steam receiver, the pump making 35 revolutions per min., and maintaining 29 ins. of vacuum in the second vessel, and evaporating from 14 to 16 lbs. of water per lb. of coal.

Fig. 7 shows an illustration of a Triple-Effect Evaporator, as used in the sugar industry.

For the rapid concentration of liquors that deteriorate by being exposed to the high temperature for any length of time, Mr. Foster has designed a Patent Film Evaporator, which is illustrated in Fig. 8. The apparatus illustrated is a Single-Effect, and is suitable for small factories. The duty of this evaporator is very high, viz., 13·37 lbs. of water evaporated per sq. ft. of heating surface per hour. The following are the average results from actual work:—Vacuum, 26·5 ins.; steam pressure in exhaust steam receiver, 6·5 lbs.; temperature in evaporator, 110 degs. Fahr.; temperature of supply liquor, 49 degs. Fahr.; specific gravity of supply liquor, 1·050; specific gravity of concentrated liquor, 1·152; temperature of concentrated liquor at discharge, 102 degs. Fahr.; temperature of condensed steam, 96 degs. Fahr.; Water evaporated per square foot of heating surface, 13·37 lb.

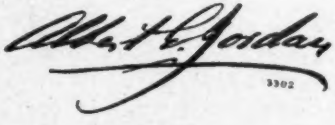
The heating tubes in the apparatus are each 4 ft. long by 2 ins. external diameter, and fitted internally with a Patent Film Tube, a section of which is shown in Fig. 9.

Each tube is supplied separately with liquor, which is concentrated to the density named above during the time it takes in passing from the top to the bottom of the tubes, and is drawn off at the bottom of the apparatus by a pump,

so that the operation is continuous, and requires little or no attention after once being started to work. The evaporator is of the ordinary vertical type, the heating tubes are placed in parallel lines, each branch supply-pipe supplying two rows of tubes. These supply-pipes are connected to a main trunk supply chamber on the side of the evaporator, from which they take their supply, and are easily disconnected when the "film" tubes require to be taken out for cleaning purposes. The top of each film tube is fitted with a liquor-spreading, or distribution chamber, as shown on Fig. 9, which shows three views of this, one in section, one on top of distributing chamber, and one showing the bayonet-catch attachment to the tubes. This chamber, as will be seen, has three legs, or ribs, with open spaces between, which rest on the top tube plate, and from which the film tube is suspended.

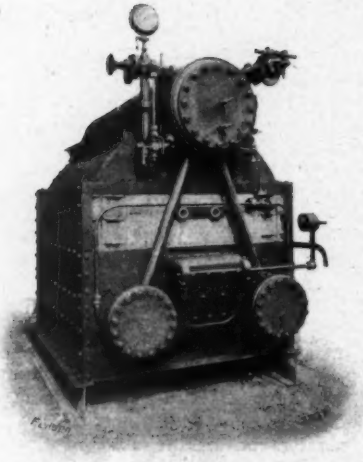
The liquor to be evaporated is fed into these chambers, and runs down the annular openings in each of these three legs or ribs, and is then distributed by the shields shown on the film tube. The annular space between these shields and the heating tube is larger at the top than at the lower end, as there is less water to be evaporated as the liquor gets to the bottom of the tube. Each film tube in this apparatus is fitted with five shields. As the liquor evaporates, the vapour passes under these distributing shields, and through the openings under the shields, and up through the centre of the film tube to the top vapour chamber, and from there to the condenser. The whole evaporating surface of the heating tube is covered with the liquor, which does not run down in rivulets. In order that the vacuum should be the same at the bottom of the tubes as in the top vapour chamber, a large vapour connection is made on the side of the apparatus, from the bottom to the top. This also takes away any vapour that might accumulate at the bottom of the apparatus.

This type of evaporator will come as a great boon to numerous industries, among which may be mentioned those manufacturing glycerine, silicate of soda, caustic soda, caustic potash, paper-makers' liquor, dye-wood extracts, meat extracts, gelatine, sugar, glucose, glue, etc., and many of which are now discarding their old evaporators for this, the most modern and successful type.



The History of the Water-Tube Boiler Controversy.

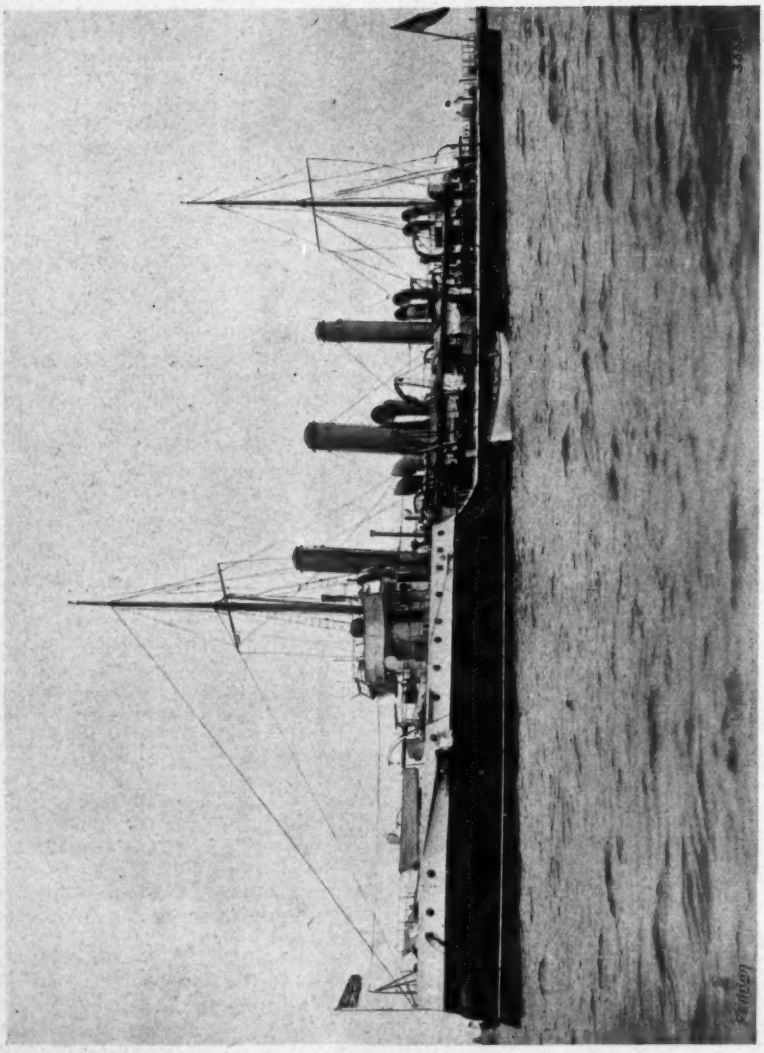
BY AN EXPERT.



THERE are two kinds of steam generators, the tank form and the water-tube, and each of these is divided into a number of types. The Cornish, the locomotive, and the return-tube marine are types of the former, the Belleville and the Yarrow are types of the latter. Since the very beginning of steam-raising, engineers and steam users have had mainly to depend on the tank or cylindrical form, and the ingenuity of the engineer has been exercised in its improvement for the last hundred years. In these latter days, therefore, the most improved types have become very efficient, and as much as 85 per cent. of the total heat in the fuel has been utilised in the evaporation of the water in the boiler. The great difficulty has, however, been in connection with high steam pressures, and often engineers who had to deal with pressures of steam above 200 lbs have been driven to use a new type of boiler. But the cylindrical or tank boiler still survives, and the highest efficiency yet attained in the generation of steam has been obtained by means of it.

In consequence of the water-tube boiler being much talked about of late in connection with the British Navy, it is often thought that it is absolutely a modern innovation. Its general use is certainly modern, but as a form of boiler it is really as old as the tank type. The early engineers of the United States turned their hands to it, and an old one of Trevithick's is still to be seen outside the walls of South Kensington Museum. One of the modern forms which has obtained a considerable degree of success was invented as long ago as 1856, and those fitted in the *Propontis* date as far back as 1870. But in all these early water-tube boilers the great difficulty was leakage. The joints could never be made tight enough, and it was not until 1893, when the *Speedy* was built, that the era of water-tube boilers came fully in, and only after that date did real competition in their manufacture begin. When pressed hard they were found less efficient than the tank form. But in very high-speed vessels, like torpedo-boats, which require to put on a sudden spurt for a short time, efficiency is sacrificed to lightness.

The present controversy began when water-tube boilers were fitted into warships in the place of Scotch marine boilers. The British Admiralty allowed Mr. Thornycroft a free hand in the fitting of his type into the *Speedy* torpedo gunboat; but at the same time had the Belleville type fitted into the *Sharpshooter*, a sister vessel. The Belleville boiler had already been fitted into several French warships, and also into several ships of the Messageries



H.M.S. "SPEEDY."

[*Symonds, Portsmouth.*

Photo by]

Company. Due to the method the French company had of working these boilers, they have met with considerable success. Some experiments and trials were made with the *Sharpshooter*, and the boilers in her were pronounced by the Admiralty authorities to be successful. The memorandum on the matter was in the following terms: "The fitting of new boilers of the Belleville type in the torpedo gunboat *Sharpshooter*, in lieu of her original boilers of locomotive type, has been completed, and they have been tested on board during prolonged trials with good results." . . . Then there is this statement: "The Admiralty have desired to encourage the production of water-tube boilers of home design, but the novelty of this class of work to most engineers of this country has somewhat delayed the completion of many of the torpedo-boat destroyers during the year." . . . . "It is proposed to adopt boilers of the water-tube type in the new ships to be laid down in 1895-96." The *Powerful* and *Terrible*, two immense cruisers, were being built at the time, and both were fitted with Belleville boilers.

At the same time as these experiments and trials were going on with the *Speedy* and *Sharpshooter*, a committee had been appointed by the Admiralty to make an enquiry and report as to types and designs of the propelling machinery and boilers employed in H.M. ships. The committee issued its final report (in which were contained "Suggestions for the improvement of the same in future") on 9th December, 1892. I shall only allude to the parts of this report which deal with the points at present at issue with regard to boilers, and which may throw some light on the manner in which the Admiralty has dealt with the suggestions made.

The first question taken in hand by the committee was with reference to the advantages of high or low pressure steam. The reference was made as follows:—

"Taking all the circumstances of the service for which H.M. ships are designed into account, is a reduction of the present working pressure considered desirable, and if so to what extent? If the committee should be of opinion that a reduction of pressure is not desirable, the reason for arriving at this conclusion should be stated."

They came to the following conclusions:—From all the steamship companies of the mercantile marine they had evidence which showed that the advantge of triple-expansion engines using steam at 150 lbs. pressure, as compared with bi-compound engines using steam at from 90 lbs. to 100 lbs. pressure, was 20 per cent. and 25 per cent. better than bi-compound engines of the old type using steam of 60 lbs. pressure.

It must be remembered that it was the return-tube type of boiler, which had to provide steam at these pressures, and when the water was pumped directly from the sea, incrustation soon began with its attendant trouble — leaky tubes. These leaky tubes gave no end of trouble, especially at the ends where the heat of the furnace was greatest.

This question of leaky tubes had to be faced by the committee, and after full investigation and discussion they came to the following important conclusion:—

"That the use of the higher pressures had but little to do with the causes of leaky tubes, for, omitting defects due to design of boilers and details of tubes, which equally affect all pressures, it is considered that the tube ends will leak in high or low pressure boilers, if the amount of power attempted to be obtained from them exceeds certain limits. When these limits are exceeded the tube ends and tube plates become overheated, owing to the increased generation of steam, rendering the local condition of circulation unable to maintain an adequate flow of water over the surface of the tube-plate; and this they regard as the primary cause of the leakage of boiler tubes . . . in our warships, the powers obtained from their boilers were sometimes unduly increased by forced draught, and the leakage of tubes which followed in consequence, should not . . . be considered as caused by high pressure."

It is on account of the Committee thus pointing out one of the chief difficulties encountered in the boiler rooms of H.M. ships—that whenever anything was said, either in Parliament or out of it, against the Belleville boiler, they were met at once with the Admiralty statement that when first the return-tube boiler was introduced it was quite as troublesome.

Then follows the momentous recommendations with regard to water-tube boilers.

"The committee recommend the fitting of water-tube boilers in two vessels for experimental purposes. It is considered those water-tube boilers

that are fitted with straight tubes of comparatively large diameter, arranged so as to be readily cleaned and examined, should be considered as suitable for trial, with the view, if found satisfactory, to their being fitted in the larger class of warships. . . . These experiments should be made without delay, so that data may be obtained for guidance as to the adoption, or otherwise, of this type of boiler. In view, however, of the requirements of the larger vessels, they further recommend that one, at least, of any new cruisers should be arranged to receive water-tube boilers, should the above trials prove satisfactory. They also consider that the *Speedy* should be thoroughly tried as soon as possible, to determine if boilers constructed with small tubes are suitable for continuous service at sea."

It may be mentioned here that the Committee, although appointed by the Lords Commissioners of the Admiralty, was an outside one, and was composed of engineers of the highest possible standing, amongst them being Mr. W. G. Manuel, of the P. & O. Company: Mr. Peter Sampson, of the Board of Trade; and Mr. J. T. Milton, of Lloyd's.

Whatever opinions and suggestions these three eminent and practical men might have made should have been attended to very earnestly by a department not run at a profit. It will be seen hereafter in what manner the suggestions were met by the Admiralty.

We have now seen the beginning of the fitting of water-tube boilers into the Navy, and we have also before us the recommendations of the Navy Machinery Committee of 1893. But now comes a new point. At the same time as the Admiralty were making experiments with the *Sharpshooter*, they sent a young engineer attached to the Navy, by name Edouard Gaudin, a round voyage on the Messageries-Maritimes steamers, which were fitted with Belleville boilers, to observe and report. On his return, Mr. Manuel put the following questions, which were answered in writing from on board the ships:—

Q. Is there any trouble in cleaning the tubes internally?

A. None whatever. Every part of the boiler is accessible for cleaning. It is much easier to clean and examine both internally and externally than a cylindrical boiler.

Q. Any trouble in feeding the boiler? how fed? if direct from the main pump, or by independent feed-engine?

A. This is, without exception, the least trouble one has with these boilers. During my voyages on these ships, one man has always had easy work to look after the feeding of eighteen boilers alight. They are fed by an independent pump of Belleville patent, one on each side of the stokehold. Once these are started they require no looking after. I consider this pump forms the basis of the perfect feeding arrangements of these boilers.

Q. Length of time the tubes have been in use before it has been found necessary to renew them?

A. In the *Ortegal* and *Sinai* the majority of the tubes have been in use for the last five or six years. They have renewed two out of 2,400 in the *Polynesian* in two years. Considering the lowest rows of tubes are 4 ins. thick, and the eight other rows ·25 in. thick, their wear cannot be great, as the circulation in these boilers, with the experience I have lately had with them, is all that can be desired.

Q. Any signs of visible priming?

A. During my voyage we had four days' very heavy seas, during which the ships pitched and rolled a great deal. I have never seen during the whole of that time the slightest priming.

Q. What is the indicated horse-power per square foot of grate at natural draught?

A. The total grate surface is 610 sq. ft. The i.h.p. at natural draught on trial = 8,000, which makes 13·1 i.h.p. per sq. ft. of grate. The usual cruising power, comprising all the auxiliary machinery, is 8,200 i.h.p., with eighteen boilers going out of twenty, and a speed of 15·8 knots in fine weather. This gives 2·5 i.h.p. per sq. ft. of grate. Steam is always easy with this boiler, except with Australian coal.

Q. How long are such tubulous boilers likely to last?

A. Without hesitation, I can say, with occasional repairs, at least ten years, and that with continuous steaming.

Q. Tubes bursting?

A. This has not occurred in the *Polynesian* since she has been running, and only once or twice in the experience of the Chief Engineer with these boilers. Nobody was hurt, and the steam simply put the fire out; as the boilers had only one ton of water each it was soon emptied. This occurred seven years ago in the *Ortegal*.

So much for the roseate report of M. M. Gaudin, which, unfortunately, it was not the good fortune of the British Admiralty to see realised.

Just before the laying down of the *Powerful* and *Terrible* there was a discussion in Europe and the United States as to England's weak point. That weak point was said to be her commerce. The ships of her mercantile marine were referred to as so many points of attack spread all over the world. To injure England it was only necessary to send a cruiser to capture or destroy the ships of her mercantile marine. As instruments of injury, Russia built the *Rurik*, France

the *D'Entrecasteaux*, and the United States the *Columbia*. The *Rurik* was of 10,923 tons displacement and made 18 knots, the *D'Entrecasteaux* 7,960 tons and made 19 knots, and the *Columbia* 7,475 tons and made 22·8 knots. The British Government answered this threat to her commerce by building the cruisers *Powerful* and *Terrible*, each of 14,200 tons and 22 knots speed. The three foreign ships were, however, fitted with cylindrical boilers, the home cruisers with Belleville boilers.

The following table will show at a glance how formidable the *Powerful* and *Terrible* appear on paper as compared with the *Rurik*, the *D'Entrecasteaux*, and *Columbia*:—

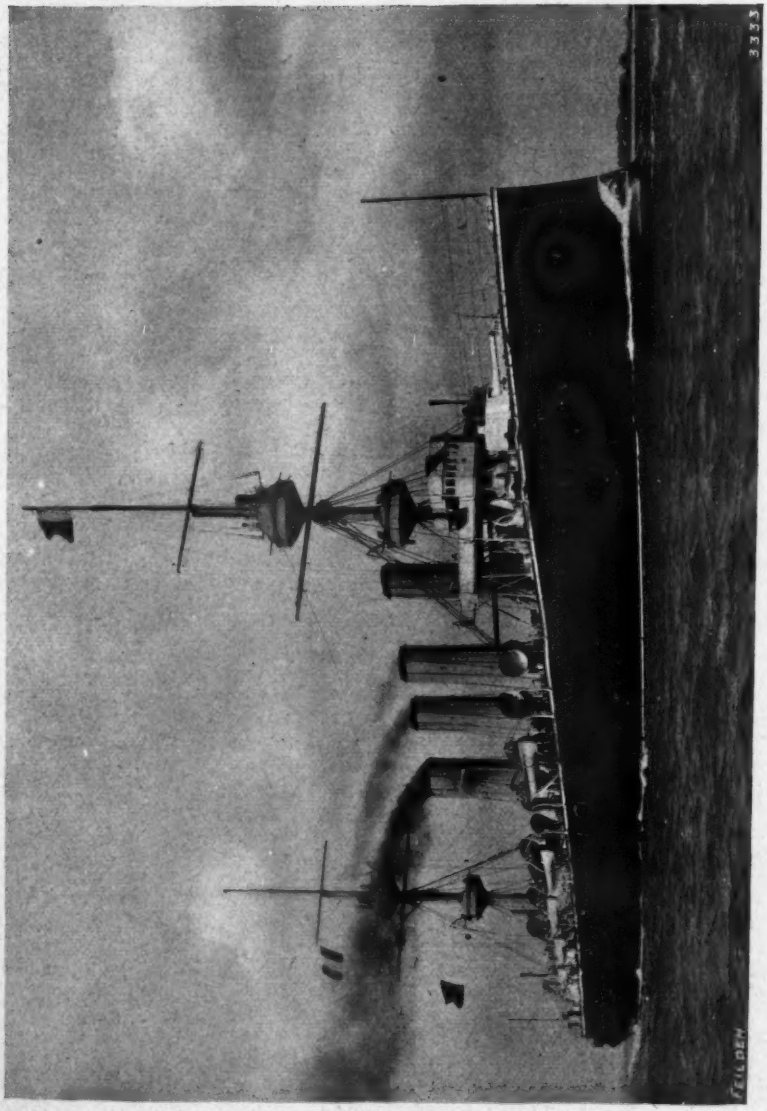
	Powerful and *Terrible*.	*Rurik*.	*D'Entrecasteaux*.	*Columbia*.
Displacement ...	14,200	10,923	7,960	7,475
Horse-power ...	25,000	13,250	14,000	21,500
Speed, knots ..	22	18	19	22·8
Coal capacity ...	1,500 to 3,000	2,000	1,000	2,400
Armament	2 9·2-in., 12 6-in. q.f. 16 12-pr., 19 small q.f.	6 4·7 q.f. 18 small q.f.	2 24-cm. 12 5·5-in., 16 small q.f.	8 4-in. q.f. 20 small q.f.

There is one distinctive feature of the cylindrical boiler. Any ship which is fitted with cylindrical boilers, and is pronounced by the builder to have a certain speed, will give that speed at any time, and, what is more, will keep it up. The *Lucania* and *Campania*, of the Cunard Line, were built for a speed of 22 knots. On trial they made it, and on a particular day of the week they sail from Liverpool or New York, and keep up the speed of 22 knots until they reach the other side. Any of the other steamers—the *Oceanic*, say—of the White Star Line keeps up its speed of 20 knots right across the Atlantic, voyage after voyage, all the year round. This was the characteristic of the *Rurik* and the other foreign commerce destroyers. Should the Russian Government order the *Rurik* to go to China at 18 knots, she would weigh anchor and steam to China at her given speed. Russian shipowners are sure of the protection which it will afford to their ships, and the Russian Government certain that she could hunt down and capture any English ship which made 17½ knots an hour.

English shipowners also were quite as certain that their ships were safe. The *Powerful* and *Terrible* correspond to an insurance paid by the English people to render their ships of commerce quite safe; and they believed in them until their eyes were opened. For example, they thought that the *Powerful*, if orders were received would weigh anchor and steam to any of the distant possessions of the country for their protection at 22 knots, just as the *Lucania* would do, or the *Rurik* at 18 knots. They thought also that if she was sent after the *New York*, which has a speed of 21 knots, she would soon overhaul that vessel.

At this time there happened to be in Parliament several engineers and shipbuilders of the very first rank. They were Mr. A. B. Forwood, the eminent ship owner of Liverpool, Mr. John Penn, of the famous Thames Marine Engine Works, and Sir E. Harland, of the largest shipbuilding yard in the world. These gentlemen, when they heard that the Admiralty intended fitting the *Powerful* and *Terrible* with Belleville boilers, at once raised their voices against it. They immediately attacked the evidence, on which the Admiralty depended for their resolution, as being flimsy in the extreme.

But up to last year the Admiralty did not meet any suggestion made to them with very good grace, persisting in going their own way. When, then, it is said that the experiments with the *Sharpshooter* were proceeded with, it must not be thought for an instant that the Admiralty were following the suggestions of the committee. The Admiralty made those experiments on their own account—they were begun before the committee reported. It was as to the way in which



H.M.S. "POWERFUL." [*Symonds, Portsmouth.*

Photo by]

the trials were made that objection was taken in the House of Commons. As a matter of fact, these trials would not even have satisfied the engineer of a small power station. In such a power station, it is usual for the engineer to arrange the trial of a new installation to be conducted under the superintendence of the contractors, and for the engines to be run for a considerable period without stopping, in order that the rise in temperature may be tested. But the trials on which depended the efficiency of a number of ships of the Navy were as nothing to this. It was stated in the House of Commons by Mr. A. B. Forwood, that steam on board the *Sharpshooter* was got up 13 times, and that the longest period of trial was only 30 hours. On so slight a foundation as this, the Admiralty resolved to fit, not a small third-class cruiser on trial (as was suggested by the committee), but two of the largest ever built, viz., the *Powerful* and *Terrible*, each of 25,000 h.p., with water-tube boilers.

Had all that subsequently happened been done, and had the Admiralty had no warning, it would not have been so bad. But all the leading engineers expressed themselves, in the House of Commons, very strongly against the action of the Admiralty. Mr. A. B. Forwood warned them as to the great increase of coal consumption the Belleville boiler would involve. The trials of the *Sharpshooter* showed that the coal consumption would be at least 2¼ lbs. per horse-power per hour, and this, in relation to the consumption on board the mercantile marine, was excessive. He knew, he said, of one vessel which steamed no less than 70,000 miles during the twelve months, and only consumed 1¼ lb. of coal per horse-power per hour. Nor was there the least advantage to be gained by any saving in weight in vessels fitted with them. The engines of the *Sylvania*, which was fitted with ordinary return-tube boilers, developed the same power as the *Terrible*, which was fitted with Belleville boilers, and the cylindrical boilers to develop this power weighed 1,235 tons, as against 1,270 tons for the boilers of the *Terrible*. Then Mr. Penn and Sir E. Harland of Belfast maintained that not the slightest experience had been gained to warrant the Admiralty in making the change, and that they had not been tried to test their staying power in rough weather at sea. It was suggested by Mr. Penn that the best that could be done before taking any other step would be to run the *Sharpshooter* for six months on end, and had his advice been taken it would not only have saved the lives of many stokers who were scalded to death, but the country a large sum of money.

The Admiralty adopted, however, a policy which has been injurious to the interests of the Navy, and issued reports in support of it which could not be borne out by the facts of the case. Breakdown after breakdown of the new boiler took place, and stokers were reported to be injured and, in many cases, killed by scalding, until the country began to become weary of the monotony of the reports, and questions were frequently asked in Parliament. Repairs were continuously going on. For example: the boilers of the *Hermes* had to be fitted with 54 new elements, consisting of 460 tubes, and the economiser had to be fitted with 18 elements; the *Terrible* with seven new elements, 78 tubes and five down-cast tubes; the *Arrogant* with 35 tubes, and the *Powerful* with 11 elements, 35 tubes, and so on.

Matters became so bad that the Admiralty at last resolved to make special trials with the *Minerva*, a second-class cruiser of 5,600 tons, and fitted with single-ended boilers of the return-tube type, and the *Highflyer*, a newer cruiser of the same displacement, and fitted with the Belleville type of boiler. It should be understood that nine second-class cruisers were first built and fitted with the old type return-tube boilers, while three new second-class cruisers, the *Highflyer*, *Hyacinth*, and *Hermes*, were fitted with Belleville boilers. The trials were supposed to be between the two systems.

These trials were watched with much interest by all nations, and opened their eyes; and every country with the exception of England has looked on Belleville boilers with a degree of disfavour since. It was

found in these trials that the *Highflyer* burned more coal at all speeds, and 16·5 per cent. more in the lower speeds. Some curious entries are made in the official reports. Against C_2 we read: "This trial was curtailed on account of defects of *Highflyer*," and against F: "Trial at full power discontinued at end of 1 hour 43 minutes, on account of defects in *Highflyer*." There were 13 trials altogether, and out of these in two cases the *Highflyer* had to stop entirely. In no case did the trial come to an end because of the *Minerva*. Then there are the following entries, which throw light on the reliability of Belleville boilers. Against A_1: "Two generator door joints and seven economiser door joints leaky; two fusible plugs renewed. These defects caused one boiler to be put out of use 4¾ hours." A_2: "Two economiser door joints leaky, and four fusible plugs renewed. These leaky doors caused one boiler to be shut off, and another substituted." A_3: "Joints of two doors leaky, causing two boilers to be shut off." B_2: "Ten joints in main steam pipe and many smaller joints leaky; 12 fusible plugs renewed." The repeated report of fusible plugs being renewed conveys a lesson. It shows that there was continued over-heating of the tubes to cause the fusible plugs to give way, since in a manner they are safety-valves to prevent damage in consequence of the burning of the tubes.

In the report on these trials made by the Admiralty with the *Highflyer* and *Minerva* the following observation is made:—

"The difference in total weight of the machinery and boilers in the two ships is about 100 tons, which saving of weight in the *Highflyer* has been devoted to giving her six 6-in. guns, instead of 4·7-in."

This statement means, if it means anything, that the substitution of water-tube for Scotch boilers in the *Highflyer*, increases her carrying capacity by 100 tons. The usual allowance of coal consumption in Scotch boilers for engines of this size is 1·5 lb. per i.h.p. per hour, which is that of first-class vessels of the mercantile marine. But, says the report:

"After training the expenditure was reduced from 3·45 lbs. per i.h.p. per hour for all purposes (which was the average of the three preceding similar trials) to 3·16 lbs. per i.h.p.

Commenting on this high coal consumption, an authoritative writer in the *Marine Française* says:

"The coal consumption of the *Highflyer* was practically double what it had been at the delivery trial, making a considerable reduction in the radius of action."

The normal coal capacity of the *Highflyer* is 477 tons; that of the *Minerva* 550 tons. Assuming, in consequence of their being sister-ships, that they make the same speed, with the same horse-power developed, it follows that the *Minerva* can steam the same distance on half-a-ton of coal as the *Highflyer* can on one ton. That is, the *Highflyer* will require 1,100 tons to make the same distance as the *Minerva* makes with 550 tons. To give, then, the *Highflyer* the same radius of action as the *Minerva*, she would have to carry 1,100 tons of coal instead of 477 tons. As the boilers are lighter in the *Highflyer* than in the *Minerva* by 100 tons, the extra load which the *Highflyer* would carry would be 1,000 tons minus 477 tons, that is, 523 tons. The *Highflyer* is thus 523 tons of displacement worse off than the *Minerva*. These conclusions are made on the assumption that Scotch boilers can provide steam to engines of 9,600 h.p. with a consumption of 1·5 lb. of coal per i.h.p. per hour.

That the radius of action of ships fitted with Belleville boilers is seriously reduced is thus sufficiently proved.

It has been stated by the Admiralty that these two ships were sister-ships, and the inference to be drawn is that the trials were conducted under precisely the same conditions. The working of the stokehold and of the engines of the *Minerva* appears to demand some qualification to this statement. The engines of the *Minerva*, it is stated, were designed to develop 9,600 h.p.; those of the *Highflyer* 10,000 i.h.p. It is usual when Scotch boilers are in use to develop the horse-power put in the bill. The engines of the *Deutschland* are designed to develop 35,000 h.p.; they developed for the whole distance across the Atlantic

36,000 h.p. The engines of the *Oceanic* are nominally capable of developing 28,000 h.p., and this was the average the whole way across the Atlantic. But the engines of the *Minerva*, which are nominally capable of developing 9,600 h.p., only gave 7,379 h.p. The Admiralty should explain why this was so much below her normal horse-power, and why it was 1,381 h.p. lower than that indicated by the *Highflyer* engines during the same trial. The speeds are not so very different. Had the *Minerva* been made to develop the same power as the *Highflyer*, the speeds would have probably been the same.

On such erroneous premises as these, we are asked by the Admiralty to believe that 61 new ships have obtained a knot higher speed with Belleville boilers. In a trial in which the Scotch-boilered ship is developing 1,381 i.h.p. less than the other, though manifestly capable of developing more, and in consequence of the rate of consumption of the Belleville-boilered ship reducing the value of its coal to half that of the other, the Admiralty have the assurance to tell Parliament and the country that if they had not

"decided to put Belleville boilers into the *Powerful* when she was designed . . . . and had waited until the whole of the minor difficulties involved in the change had been overcome, the magnificent fleet which has been built, building, and projected since that time—consisting of 20 battleships, 22 armoured cruisers, 10 protected first-class cruisers, and 9 second-class cruisers, making a total of 61 ships—would have had at least a knot less speed than they now have."

This, in the face of the facts that the *Highflyer* did not make a higher speed than the *Minerva* when the same power was developed, and that to give the *Highflyer* the same cruising radius she would require to carry 523 tons more coal.

These trials, which have been found so satisfactory to the British Admiralty, have been viewed with misgiving by the naval authorities of other countries. The Russians have fitted their latest fastest cruiser with boilers of the Niclausse type, and she steams 23 knots an hour on natural draught. The United States Navy has condemned the boiler from a mere inspection of the drawings, and even the French authorities are becoming alarmed at what they have done in fitting this boiler into their ships of war. An authoritative writer in *L'Eclair* says:—

"One of the principal difficulties to be solved in the Navy is that of endowing the ships with the best boilers. All the maritime powers have been endeavouring for a number of years to find the type of boiler which will meet all the requirements of economy, power, and security, but the problem has remained unsettled, and the solution has not yet appeared. . . . *L'Eclair* has several times urged that comparative trials be made with the different systems in use in the French Navy, in order to note the results obtained, and draw from them useful lessons. We have asked that trials be made with three ships of the same power and tonnage, the *Bergeaud*, the *Friant*, and the *Chasseloup-Laubat*, which exactly meet the conditions. . . . The coal consumption per horse-power per hour for the boilers of the *Highflyer* was almost double that during the acceptance trials. These results prove how little confidence can be placed in the latter trials, which everybody, contractors and Admiralty alike, are always interested in showing forth as excellent. This series of experiments, therefore, gives the advantage to cylindrical boilers, showing less consumption of coal, greater regularity of action, less inertness of apparatus, and greater promptness in restoration to a condition of service. . . . It is not to be denied that the water-tube boiler, as compared with cylindrical boilers, shows military advantages upon which its use on warships rests, but it should be known how to choose among the types employed; and that is why we demanded in 1896 and 1898, as we still demand to-day, that earnest experiments be made with the different types actually in service. . . . Small tube boilers are difficult to examine, clean, and repair; so much so that boilers of this model cannot undergo a service of 1,200 or 1,500 hours of heating without it being necessary to change the whole tubular system. . . . We should show proof of wisdom if, like our neighbours, we would take the trouble to assure ourselves in advance of the comparative value of the implements of warfare which modern inventions place at our disposition."

(To be concluded.)

Geo. Halliday

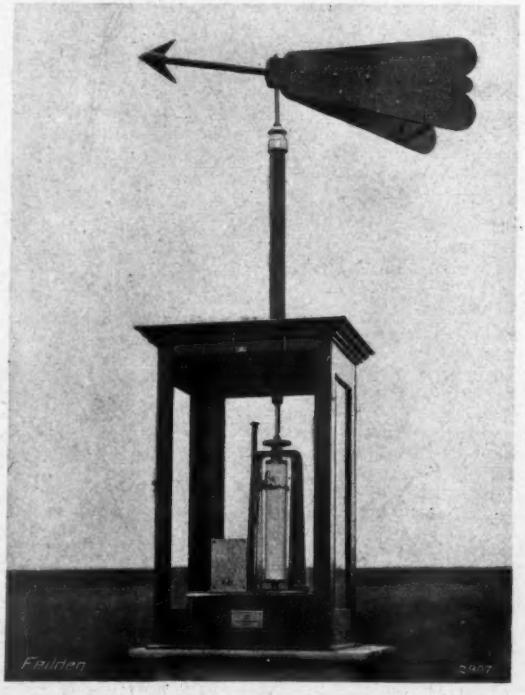
New Machinery. Appliances. Structures. & Processes.

The Editor of FEILDEN'S MAGAZINE cordially invites his readers to send him early particulars of New Structures, Machinery, Improvements, etc., for inclusion under this section. FEILDEN'S MAGAZINE undertakes the whole of the cost of illustrations, merely stipulating that proper details, photos, blue prints or tracings are supplied. Where necessary, we will send our editorial representative to inspect and report on any special subject. The Editor, however, reserves to himself the right of accepting or rejecting any matter.

IMPROVED METEOROLOGICAL INSTRUMENTS.

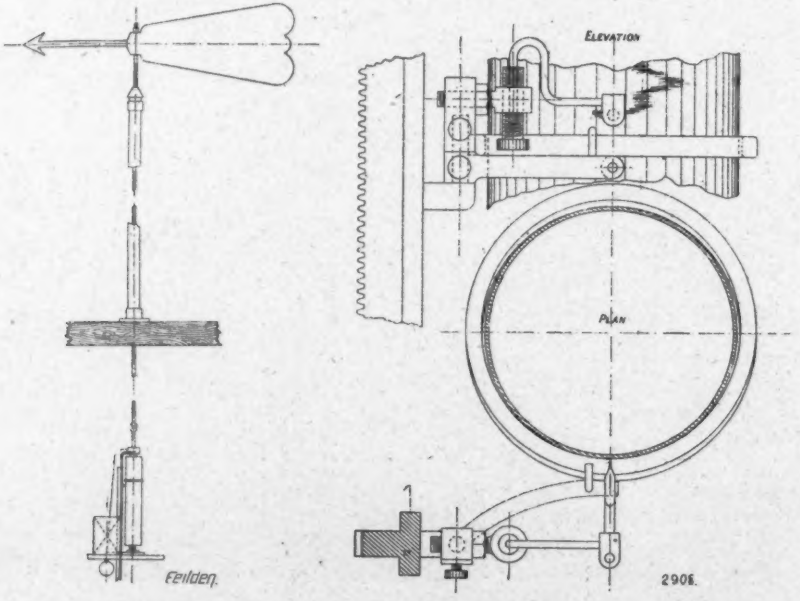
A NEW SELF-RECORDING ANEMOSCOPE.

THE number of instruments invented since the birth of true experimental science for registering the rate and the direction of the wind is so great that to mention the names of the inventors only would require many pages of this magazine, and yet the progress made in the science of anemometry has been very slow. For a long period—*i.e.* from the days of Hooke—in the middle of the seventeenth century, until a comparatively recent period, all observations were vitiated by the idea that the most important elements to be ascertained were direction and *pressure*, while what we really ought to know in order to place meteorology on a more reliable basis are direction and *velocity*. It would be simple enough to deduce velocity from pressure if we had to deal with approximately uniform air currents, but in reality their variability is so great that such a deduction is quite impossible. It was Dr. Whewell who first drew attention to the necessity of recording velocity instead of pressure, and who devised an instrument for this purpose extensively used by himself in his observations, and strongly recommended by Sir W. Snow Harris to the British Association in 1841 for adoption. Owing, however, to some faults in construction, among them the use of toothed wheels and endless screws offering great frictional resistance, and rendering of little use the records especially of gentle winds, it became soon obsolete. Dr. Robinson's cups

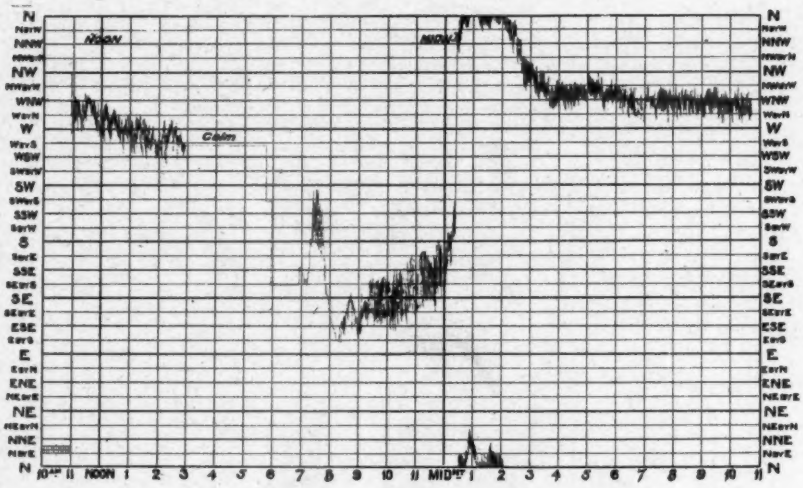


NEW SELF-RECORDING ANEMOSCOPE.

and anemometer, in which the cups move at almost exactly one-third of the rate of the wind, marked a great progress as far as the measurement of velocity was concerned, and he also invented a self-registering apparatus to which the central cups were fitted. An instrument for recording velocity as well as direction, far superior as regards both compactness and accuracy to Dr. Robinson's anemometer, was later devised by Mr. Beckley, of Kew Observatory, and is fully described in the "Report of the British Association," 1858, p. 308. This so-called "cups-and-vane anemometer" is provided with a self-recording device, consisting of a cylinder which carries a register sheet, over which two pencils press lightly. This is turned at a uniform rate by clock-work, making a complete revolution in 24 hours, moving at the rate of half-an-inch per hour; and the register sheet gives a complete record for that period. Neither this apparatus, however, nor similar ones invented later have given even moderate satisfaction as far as a record of direction is concerned, since, as Mr. Joseph Baxendell, F.R.Met.S., pointed out in a paper, read before the Royal Meteorological Society two years ago, they were not sufficiently delicate to show the short-period, but very definite, variations in the direction of the wind which undoubtedly exist even in the most open situations, and form a feature quite apart from the momentary gusty oscillations. These variations are of considerable importance in determining the nature of the wind blowing at any given time. Moreover, these instruments frequently give but an imperfect record of the rapid and instructive movements of the wind in azimuth during thunder weather. Those in which the record is produced by electrical means, as for instance the instruments designed by MM. Richard Frères, and in which "beak pens" may be used, have the great disadvantage of giving the direction of the wind merely to the nearest principal point of the compass; and a common drawback of all the older anemometers is, that the direction apparatus is associated with that for recording the velocity or pressure, while it is very desirable to have a separate and continuous record of direction. Such a record is supplied by the Wind Direction Recorder, or Self-Recording Anemoscope, described below, and illustrated by the accompanying figures. This instrument was designed by Mr. Baxendell, and has been in use now at



DETAILS OF NEW SELF-RECORDING ANEMOSCOPE.



A RECORD TAKEN WITH THE NEW ANEMOMETER.

the Marshside Station of the Fernley Observatory, Southport, for a sufficient length of time to test its value.

An exceedingly light, but large, double-bladed spread vane, the blades of which are of aluminium, and 2 ft. 6 ins. in length, measured from the axis of the vane, while their width is 15 ins. at the tips, is mounted on an also light, thin, tubular, long steel spindle, the entire weight of both vane and spindle being carried on ball-bearings placed a short distance below the vane, and in turn supported by a 2-in. gas-barrel iron pillar enclosing the spindle, and resting on a flange bolted to the roof of the substantial hut containing the recording portion of Dines' Anemometer. The vane is upwards of 30 ft. above the roof of the hut, and could be fully 40 ft. without injuriously affecting the action of the instrument; it is convenient to fix it five feet or so lower than the vane of Dines' Anemometer. The pillar is guyed at two points in its height by sets of three steel wire ropes, connected to anchors through the medium of screw-tightening and adjustment hooks. Inside the building a Hook's joint is provided, and also square slipping pieces (in view of contraction and expansion of the long spindle). The spindle, near its lower extremity, which terminates in a suitable bearing, is encircled by a drum rotating with it, on which the chart is wrapped, one end of the paper (from which that particular margin has been cut off) simply overlapping the other end, the join being at "North" on the chart. The drum is steadied by a simple bracket-bearing placed immediately above its upper end, and constructed of patent Magnolia antifriction metal. The chart-sheet is secured by circular spring clips at the top and bottom of the drum. A Dines' Anemometer pen is carried on a stout vertical rack of sufficient weight to drive the clock by which its descent is regulated. Attached to the rack, and immediately underneath the penholder, is a short brass arm extending to or past the centre of the face of the drum, and passing fairly close to it. On this arm rests the front of a solid bevelled metal ring, which, slipping *loosely* over the drum, encircles the chart; the back of the ring, therefore, by its own weight, falling somewhat lower than the front, thus keeping the overlapping end of the chart (*i.e.* the join) tight and neat, especially when opposite the pen, no matter in which direction the drum is revolving. A ring can be made which does not add perceptibly to the friction, and yet acts extremely well. A small hook is, however, attached to the arm to prevent all possibility of the ring sticking at any time.

Mr. Curtis's pivoted pen will pass over the simple overlapping join of the chart under these circumstances perfectly, in either direction, provided only that the chart is so wrapped on the drum that the exterior edge of the join does not (when in the neighbourhood of the pen) face the penholder's axis, but is in the opposite direction, and of course the charts are printed accordingly and are

suitably cut. Precautions are taken to secure rigid and permanent accuracy in regard to orientation; but facilities are provided for disconnecting the drum when changing the charts, and for lubricating and cleaning each of the bearings. Though the instrument above described is sensitive even in light airs, it is very steady in the strongest gales. A damping arrangement, such as that adopted by the Meteorological Office, can readily be added, however, if desired, and in indifferently exposed positions would probably be important; but with a thoroughly open exposure, damping is not requisite in any weather.

The instrument is made by Mr. F. L. Halliwell, 2, Hill Street, Southport.

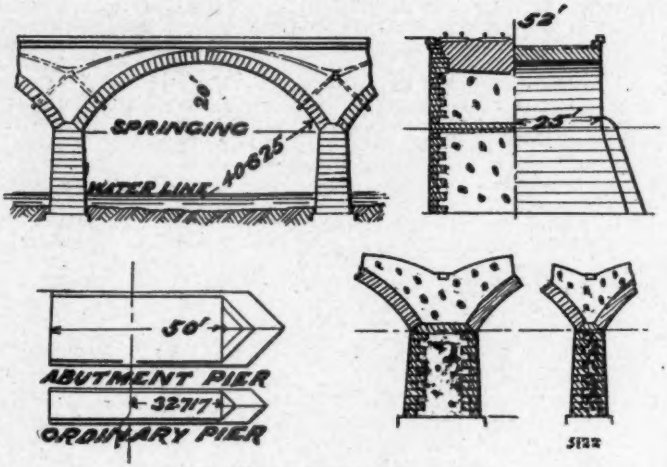
THE ROCKVILLE STONE ARCH RAILWAY BRIDGE.

THE four-track bridge of the Pennsylvania Railroad, across the Susquehanna River at Rockville, five miles above Harrisburg, is among the longest stone arch railway bridges in the world, and has a total length of about 3,820 ft., a minimum width of 52 ft. over all, and a height of 51 ft. from the low-water level to coping. It has 48 70-ft. segmental arch spans, which are built with cut-stone voussoirs, ashlar pierfaces, and spandrel filling. It contains about 100,999 cub. yds. of masonry of all sorts. The increase in volume of traffic and weight and dimensions of rolling stock, and the improvements of the roadbed, made it necessary to build this bridge to replace a double-track through-truss iron bridge of 23 120-ft. spans, which was built in 1874 at nearly the same site.

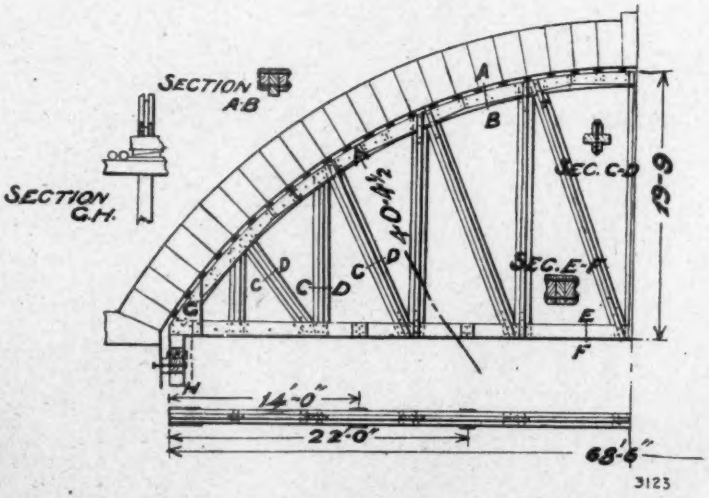
The new bridge is mainly of interest on account of its magnitude and the methods and plant by which so much important work has been rapidly executed. The axis of the main part of the bridge is a straight line, making a small angle with the axis of the river, and intersecting the axis of the old bridge about 200 ft. east of the east shore line, beyond which point the old structure diverges upstream from the new one about 450 ft. in the width of the river. The spans are supported on 47 piers and two abutments, all founded on solid rock only about 5 ft. in maximum depth below the low-water level. The bridge is divided into six sections of eight spans each, and at the ends of sections the river piers are made extra heavy, with a transverse thickness of 19 ft. at the springing line, so as to provide independent stability for the arches on both sides, and arrest there the possible progressive collapse of successive arches if one should be destroyed and the intermediate piers should fall under the unbalanced thrusts.

The north, or upstream face, of the bridge is a straight line from the east end to the forty-fourth pier, and the south face is parallel to it from the west end to the fourth pier. Beyond these respective piers the north face curves upstream at the west end, and the south face curves downstream at the east end, so as to increase the width of the bridge to about 100 ft. at the abutments, a modification effected simply by curving the masonry of the divergent face, and cutting the ring stones to the required angles without changing the regular bond and coursing of the voussoirs. This feature is adopted to avoid a larger skew in the bridge axis and relieve the curves on which the tracks enter and leave the bridge, and at the east end allows two extra tracks to diverge from the main lines before they leave the bridge. The tracks are on a level grade across the whole length of the bridge, and are 7 ft. above the intrados at the crown and 27 ft. above the springing line. The springing line is at about the level of the great flood of 1889, and is 19 ft. above ordinary spring water-level, and about 23 ft. above the average level of the rock bottom. At the east end of the bridge the tracks deflect downstream from the centre of pier four on a 6-deg. curve, and at the west end they deflect upstream from the centre of pier on a 5-deg. curve.

The details and dimensions of the piers and spans are shown in the accompanying elevation and sections. The intrados is a segmental curve of 40·625 ft. radius, 70 ft. clear span and 20 ft. rise. The extrados is parallel to it, with a radius 42 ins. longer, thus giving a uniform depth to all the voussoirs except the key-stone, which is 48 ins. deep. The 46 voussoirs are 1 ft. $9\frac{7}{32}$ ins. thick on the intrados, and 1 ft. $11\frac{1}{16}$ ins. thick on the extrados; the key-stone is about 3 ins. thicker, and all radial joints are $\frac{1}{4}$ in. thick, giving total lengths of 84 ft. $4\frac{5}{16}$ ins. and 91 ft. $7\frac{7}{16}$ ins. to the intrados and extrados respectively. The skewbacks are about 4 ft. wide, 9 ins. high at the upper edge, and project 1 ft. beyond the extrados. On the intermediate piers the skewbacks for the adjacent arches are in contact, and together form a coping course completely covering the top of the pier. The longitudinal spandrel walls and pier faces are of rock-faced ashlar sandstone from local quarries laid in 2-ft. courses. The centres of the piers and the spandrels up to 16 ft. above springing line are filled with Portland cement



ROCKVILLE RAILWAY BRIDGE: GENERAL DETAILS.



ROCHVILLE RAILWAY BRIDGE: CENTERING EMPLOYED FOR THE ARCHES.

and limestone concrete, which has a waterproofed upper surface dished to sumps over the pier centres, whence the drainage is discharged by cast-iron pipes carried through the soffits of the arches. On the concrete there is a cinder fill to sub-grade, above which there is a standard broken stone ballast. There is about 35,000 yds. of concrete, and an equal amount of cut stone arch-sheeting in the bridge, the remaining 30,000 yds. being ashlar face masonry.

At the site the water is shallow and has a slow current over a comparatively smooth, regular rock bottom. Work was commenced on the foundations in April, 1900, and the contractors were fortunate in having a very dry season, so that the pier footings were built in water usually 3 ft. or less in depth, and were completed at the rate of six a week, the first being finished on May 20, and the last on July 31. Timber cofferdams were built on shore, floated to position, sunk, and puddled with clay. They were emptied by steam pumps, and the leakage was removed by steam syphons. The unsound surface rock was removed, and the footings levelled up with concrete. Pumps and derricks were installed on flatboats, and materials were delivered on a service trestle alongside the bridge. All work was carried on simultaneously by two contractors, who pursued similar methods, installing corresponding plants on opposite ends of the bridge.

Each arch was built in longitudinal halves, the first being completed to the axis of the bridge, after which the centering was moved transversely out from under it into place for the second half, which was built and bonded into the first, after which the spandrel walls and filling were completed at leisure. The centres were segmental trusses, made of solid squared timber with horizontal bottom chords, vertical posts, and single inclined members, with panels from 6 to 8 ft. long, as shown in the accompanying elevation. The top and bottom chords were each made of three 4 by 12-in. pieces, and the vertical and diagonal members were each made with one 4 by 12-in. centre-piece and two side pieces, so that the former could pack between the side pieces of the chords, to which it was securely bolted, while the ends of the side pieces were scabbed over the sides of the chords. At the ends of the trusses the top and bottom chords were connected by pairs of triangular $\frac{5}{8}$-in. steel side plates 4 ft. high. The trusses were set about 4 ft. apart and were connected together in groups of seven, enough for the half arches, by 3-in. by 6-in. lagging strips about 21 ins. apart on centres, which corresponded to the horizontal joints of the sheeting, and supported the voussoirs at the edges only. The trusses were seated at each end on a single 12-in. by 12-in. transverse sill 50 ft. long. Under each truss the sill had a bearing on a parallel 50-ft. cap, with two white oak wedges and a 3-in. block. The cap formed the top of a two story trestle bent, with its bottom sill seated on the offset of the concrete footing close to the pier. The bent had thirteen 12-in. by 12-in. vertical posts and a middle horizontal timber, the posts being spaced so as to be in the planes of the trusses.

After one-half of the arch spans was completed the wedges were slacked off, and the sills lowered to bearing on 6-in. rollers, on which the trusses were moved transversely to the other side of the arch. When the span was completed, the arch-centre trusses were shifted to the next span by floating 15-ton boom-derricks on 30-ft. by 50-ft. scows which had been used for building the pier masonry. In each set of centres, besides the seven trusses under the sheeting, there was an eighth truss near the axis of the bridge to carry one rail of the traveller track, and each contractor had 84 trusses, so that work could be maintained on laying the sheeting of several arches at once. At each end of the bridge the masonry and materials were handled by three stiff-leg boom derricks, travelling on a 20-ft. gauge track having one rail supported just beyond the axis of the bridge, and the other rail near the edge, both being carried between the piers by trestle-bents, supported on the false-work trusses or the finished arches. There was one material track at the outer edge of the bridge, and none on the centre line.

Each arch contains 2,350 ft. of sheeting, which was laid in about five days. The mortar was mixed by hand on the bridge as used; concrete was mixed in a Cockburn square-drum power machine on each shore, and, with the stone, was delivered by cars drawn by narrow gauge locomotives. The stone was quarried by the contractors, cut and stored in large quantities in yards at the ends of the bridge, where it was handled by ordinary steam derrick. About 300 men were employed at the bridge site by the Drake & Stratton Company and by Mr. H. S. Kerbaugh, both of Philadelphia, to whom the contracts for the east and west halves of the bridge, respectively, were awarded.

We are indebted to the *Engineering Record* for the particulars and plans, which latter were prepared in the engineering department of the Pennsylvania Railroad, Mr. Wm. H. Brown, chief engineer, by Mr. H. S. Righter. The construction was in charge of Mr. Righter and Mr. George Naumann, assistant engineers.

4-FT. BORING AND TURNING MILL WITH TAPER-FORMING ATTACHMENT.

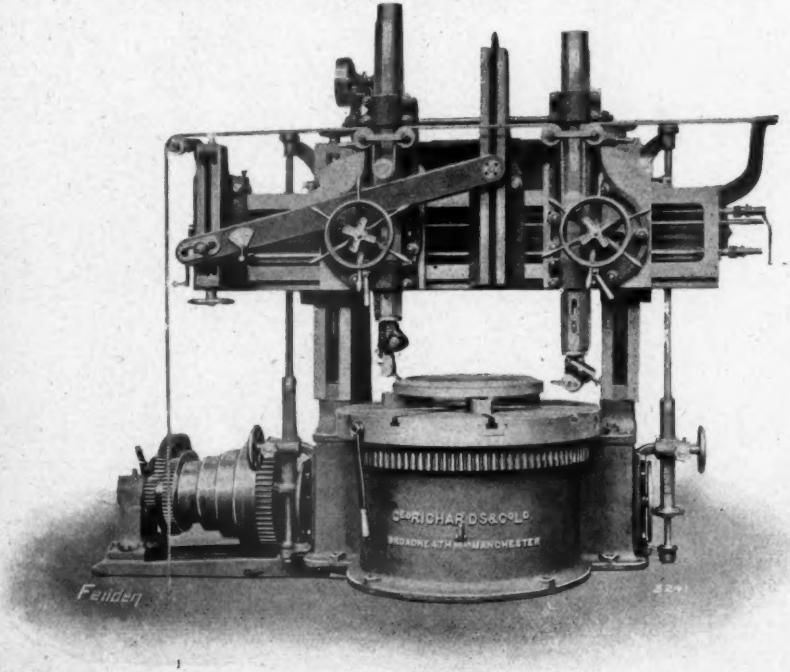
THE illustration below shows a 4-ft. boring and turning mill, as built by Messrs. Geo. Richards & Co., Ltd., Broadheath, nr. Manchester, and fitted with a taper-forming arrangement for turning slight tapers, such as are required on steam-engine cylinder covers, bevel-wheels, and so forth, and which could not be got by the swivelling of the ordinary rams on the machine.

The arrangement consists of a former bar, which is attached to one of the rams by a sliding and swivelling block. This bar is carried on brackets mounted on the cross-slide, one bracket being fitted with a screw for giving varying tapers. The fulcrum pin of the bar slides in a T-slot, and can be clamped in any position, thus allowing of a moderate adjustment for dealing with varying depths of work, and rendering it only necessary to raise or lower the cross-slide when considerable adjustment is required. The bar is fitted with a gravity indicator to the angle to be turned, and the arrangement is equally as applicable to the turning of interior tapers as exterior tapers.

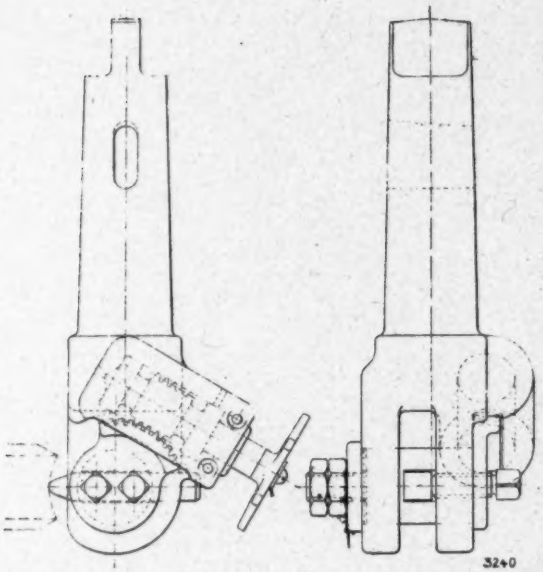
When the former attachment is being used, the ram being connected to the former bar, makes it that a cut cannot be put on by the ram, and to compensate for this, a special tool-holder with a vertical adjustment is employed.

The illustration shows the machine operating on a worm-wheel blank, viz. turning the taper on the edge of the rim, and, at the same time, turning the concave groove for the worm in the rim. This latter operation is performed by a special tool-holder, which allows of the tool being moved radially, either by tappet placed on the table to engage with the star-wheel, or by hand. This tool-holder is shown to the right in the illustration, also in detail by separate illustration given on next page.

Messrs. Richards build boring and turning mills to deal with diameters from 3 ft. up to 16 ft., and they make the machines either with friction or positive feeds. In the case of the latter, they provide 12 rates of feed, and these have a range from $\frac{1}{32}$-in. to $\frac{3}{4}$-in.



4-FT. BORING AND TURNING MILL WITH TAPER—FORMING ATTACHMENT OPERATING ON A WORM-WHEEL BLANK.



BORING AND TURNING MILL.—SPECIAL TOOL HOLDER FOR USE WITH FORMER ATTACHMENT.

All their mills up to the 90-in. size are self-contained, thus obviating the necessity of a pit, and no expensive foundation is required.

A NEW FEED CHECK VALVE.

THIS valve, illustrated in Figs. 1 and 2, herewith, has recently been placed on the market, under the title of Green's Patent Accessible Feed Check Valve, by Messrs. Shipham & Co., Ltd., Hull.

The valve consists of a shell casing *a*, with cover *b*, gland *c*, and spindle *d*, and is in these respects similar to check feed valves of the usual construction, the precise form indicated by the drawing being given for the purpose of illustration only; but instead of the usual single valve and seat, two valves *e* and *f* and two seats, *e1* and *f1*, are provided. The top valve seat *e1* is formed in the shell casing *a*, and the top valve *e* is on the end and forms part of the valve spindle *d*, the bottom part of this valve being recessed for the reception of the spindle of the bottom valve *f* which works into it, and by means of which the lift of the bottom valve is regulated. The bottom valve *f* forms the check valve proper for feeding the boiler, and its seat *f1* is a separate casting, the shell being bored and the seat turned to fit the one to the other. In the bottom of this seat are two holes *g1 g2* tapped through lugs or a flange, *f2* for the insertion of eye-bolts to enable the bottom valve and its seat to be readily withdrawn for repairs. In addition to the usual packing gland and stuffing box for keeping the spindle water-tight, the valve spindle extends through a top part *c1* external to the gland and is shouldered against a screw cap *h* fitted on same, so that by screwing the cap down, the valve spindle *d* and top valve *e* is pushed down to

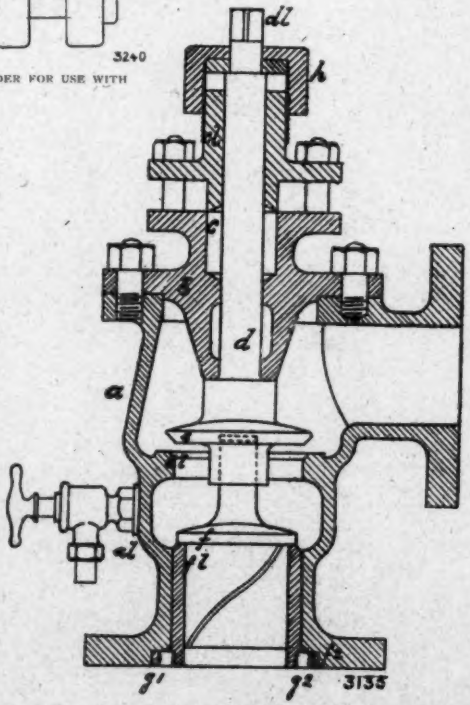
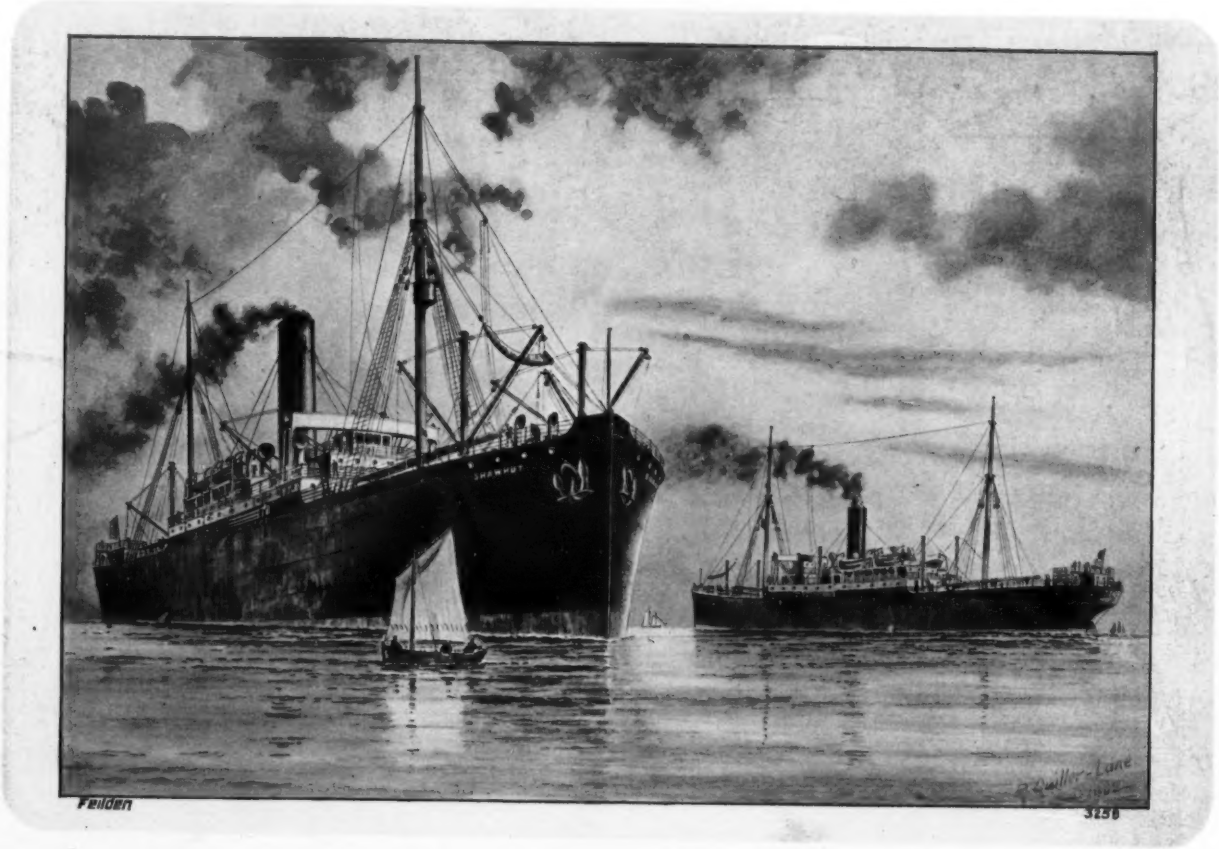


FIG. 1.—VERTICAL SECTION THROUGH GREEN'S PATENT ACCESSIBLE FEED CHECK VALVE.

SUP



CARGO STEAMER "SHAWMUT,"
BUILT FOR THE BOSTON STEAMSHIP CO., BY THE MARYLAND STEAM CO.

See page 253.

its seat when required. The end *dl* of the valve spindle is made square for turning the valve round when closing, so that any dirt or grit lodged on the seat may be ground off. A boss *al* is placed on the external side of the shell casing to insert a cock for relieving the pressure between the two valves before drawing the bottom seat.

The construction renders it unnecessary to blow down the boiler in the event of grit or any foreign substance becoming lodged under the seat of the working valve, as by closing the top valve connection is shut off and the bottom valve and its seat can be then drawn for inspection or repairs.

They are supplied with either mitre or flat faces, and with screwed or plain spindles.

FIG. 2.—EXTERNAL VIEW OF GREEN'S PATENT ACCESSIBLE FEED CHECK VALVE.

THE TWO NEW TWIN-SCREW STEAMSHIPS FOR THE BOSTON STEAMSHIP CO.

BUILDING BY THE MARYLAND STEEL COMPANY, SPARROW'S POINT, Md., U.S.A.

OUR supplement plate depicts two fine vessels, the first of which, named the *Shawmut*, was launched a few weeks ago, her sister being at present plated. They are the largest cargo steamers ever constructed in the United States of America, being of 11,000 tons dead-weight capacity.

The entire hulls are of mild steel, built to conform to the rules for the highest rating of the British Corporation Society.

There are three complete steel decks, extending stem to stern, with a steel bridge deck amidships extending for 178 ft. Nine hatches extend through all decks, and four watertight bulkheads extend to the upper deck, and one to the main deck, forming a deep tank.

The fore and after peak bulkheads rise to the shelter deck, two ordinary bulkheads extend to main deck, one forward of boiler-room bulkhead, forming a reserve bunker, and one between the engines and boilers.

They are constructed with a cellular double bottom with a capacity of 2,100 tons water ballast, and 770 tons in the deep tank forward of the boilers.

The framing adopted is of the "deep-frame" type, with three heavy hold stringers on each side, with a similar one worked in between main and upper deck. The deck beams are on alternate frames on main and upper decks, and on every frame on shelter and bridge decks. Stem and stern posts and hangers are of cast steel, the rudder being of the single-plate type, now so general.

The shell plating is arranged on the "clinker" system, and is bossed out to include screw-shafts, known in the States as the "Lundborg" system, but originated here by Harland & Wolff.

These vessels will be driven by triple-expansion engines, one set to each screw, of the well-known direct-acting inverted cylinder type, the cylinders being 23½ ins.,

BIRDSEYE VIEW OF THE WOLVERHAMPTON EXHIBITION.

39½ ins., and 63 ins. by 45 ins. stroke, and are supplied with steam at 200 lbs. pressure by four single-ended boilers, 15 ft. 6 ins. diameter by 10 ft. 9 ins. long. Each boiler has four 39-in. furnaces, giving a total grate surface of 276 sq. ft., and a heating surface of 10752 sq. ft., and provided with Howden's system of forced draft. The general dimensions are as follows :—

Length between perpendiculars, 488 ft. ; over all, 505 ft. ; beam, moulded, 58 ft. ; depth to main deck, 22 ft., to upper deck, 32 ft., to shelter deck, 40 ft., to bridge deck 47 ft. 6 ins. ; depth of double bottom, 4 ft. 2 ins. ; draft, loaded, 27 ft. 3 ins. ; dead weight capacity, 11,000 tons. Sea speed (estimated), 12 knots.

A very important particular in these ships will be the very complete installation of winches and derricks for the expeditious handling of cargo. The foremast will have eight derricks, the mainmast six, while four derrick posts will have two each, and two—amidships—one derrick each, with twelve powerful steam winches to work them.

The officers, engineers, etc., will be located amidships, while the crew will be provided with superior accommodation aft, under wheel-house, where baths, etc., are placed for their use.

Electric light will be provided all over, and a most complete system of ventilation adopted.

THE WOLVERHAMPTON ART AND INDUSTRIAL EXHIBITION.

THE Exhibition, which it has been decided to hold in Wolverhampton in the Summer, will be the most important ever held in England since the great Jubilee Exhibition held in Manchester in 1887.

The undertaking has already met with most hearty and widespread support from all classes. The Corporation of Wolverhampton and other important municipalities have given the undertaking their support, and the civic heads have become Vice-presidents of the Exhibition. Excellent technical assistance has been secured to carry the project through, in the persons of Mr. H. A. Hedley and his Assistant Mr. Cundall, who so ably managed the recent exhibition at Glasgow; and Messrs. Walker & Ramsey, Architects, of Glasgow, have been made responsible for the buildings.

The site of the Exhibition, over thirty acres, is part of the West Park of Wolverhampton, which has been granted by the

Corporation, as well as the adjoining grounds, which have been lent by Lord Barnard.

The scope of the Exhibition is a wide one, and will include a full illustration of the engineering industries and industrial and scientific products of the British Empire and of foreign countries, special attention being given to the development of electricity and of means of transport and locomotion, for the display of which accommodation is well provided.

The buildings are situated in West End Park, contiguous to west parts of town, and in close proximity to tram-lines and main thoroughfares, etc.

The Industrial Hall, Canadian Pavilion, and Machinery Hall form a crescent, facing the main avenue, and command the full extent of park, a small restaurant being placed in rear of Canadian Pavilion.

In the design of the various buildings precedent has practically been ignored, and an endeavour made to reflect artistically their contents and use.

The Industrial Hall, forming the north-east termination of the crescent, is of light and graceful design. The main façade shows an open arcade (utilised as a tea terrace), with centre and end features. The central feature, being the main entrance, is recessed and decorated with a free stencil treatment in colour; while the towers, which rise to a considerable height, are capped by open lanterns. The end features resemble the centre, horse-shoe doors being introduced, but being of less importance, and to give the necessary harmony and proportion, are not so strongly accentuated, low octagonal corners taking the place of towers; the doors, however, are recessed and stencilled in similar manner to the main door. The end elevations are alike, the façade being pierced with windows in place of open arcade as in front, with an entrance in the centre emphasised by towers. Internally the hall is divided into three bays, with half bays additional at front and back, the half bay in front forming an arcaded tea terrace, while that in rear is absorbed in the hall. The roof, which is largely glazed, is supported by semicircular ribs sufficiently lightly constructed to impart a very airy and graceful effect. A distinct innovation in a building of this nature is a musicians' gallery placed over the entrance in East Elevation, which will be utilised for band performers in wet weather.

The Machinery Hall is designed on robust but simple lines. The main front, which faces the south-west elevation of the Industrial Hall, is circular in outline, this form being determined by contour of roof (which is constructed on the bow-string principle). The main entrance door is elliptical in outline, and has a colossal figure of Industry over it. There is a tower on either side of the door, and lesser towers flank both ends of front. The circular parapet is surmounted by a large circular fan, which, along with other features in this elevation, has been treated with a view to artistic electric-light effects at night.

The side elevation is of simple but graceful design. Internally, the building is divided into three bays, the centre bay being 60 ft. wide and the side bays each 35 ft. wide.

The total number of exhibitors will be about 300, exclusive of those of Canada, India, and Japan.

The boilers, which will generate the steam for the motor power used in the Exhibition, for lighting, and also for driving machinery, are of quite a new type in this country, and are being introduced for the first time.

The general collection of electric generating plant is being exhibited by a number of the leading firms, and will include machinery with all the very latest improvements. The distribution of the various electric sources of supply will be on quite a novel system.

There will be a very complete exhibit of printing machinery, for producing books from start to finish. These will mainly be of American machines which have only quite recently been introduced into this country.

The machine-tool exhibits and the wood-working exhibits will also be very extensively shown by firms of the highest repute in their various branches of trade, all the machinery being shown in operation.

Examples of all the very numerous local manufactures, as well as manufactures from all parts of England and Scotland, will be found in the Industrial Hall. In addition to these the Canadian Government are making, in a pavilion which they are erecting, a very extensive display of the raw products of Canada, and in many cases the manufactured articles which the Dominion exports.

We shall, in the next issue, deal fully with the plant supplied for generating the motive power, together with the electrical equipment.

WORKSHOP PRACTICE

Practical suggestions for this section are invited, which, if accepted, will be suitably paid for. Wherever possible, drawings should accompany the contribution; rough sketches will suffice. Nothing will be too poor for a careful inspection. See important announcement in advertisement pages.

❀ ❀ ❀

Artificial Refrigeration for Workshops.—In most summers there are several weeks during which the hot weather prevents us from doing as much work as we are normally capable of. During this past summer there have been several such weeks, when the amount of work done by each person has been very materially lessened. This is not only very uncomfortable physically for the worker, but is a source of considerable loss to the employer, both directly in wages paid for work not done, and indirectly in lost contracts through inability to fulfil the conditions as to delivery within reasonable time. The remedy lies in cooling the workshops to a reasonable temperature, say 60 degs. to 70 degs. Fahr., and then removing such additional heat as finds its way in. The amount of heat requiring removal depends on the size and initial temperature of the room, also on its position, whether adjacent to a boiler-house, or being exposed to the sun's rays. If work commences at, say, six to eight o'clock in the morning, the room will then, as a rule, be reasonably cool, and the problem left is, how to absorb such heat as finds its way into the room during the day. The amount of this heat depends—apart from the presence of stoves, steam or gas engines, etc., in the room—on—(1) *relative* temperatures of outside and inside of room; (2) nature of the walls of room; (3) thickness of walls of room; (4) quantity and temperature of the fresh ventilating air drawn in. These, it should be noted, are exactly the conditions determining the quantity of heat necessary to warm the same room in winter. Now, since it is found not only practicable but profitable to heat workrooms in winter, it would seem probable that it would be also profitable to cool them in summer, the methods employed being cooled air currents, air propellers, electrically-driven fans, &c; and there are small refrigerating installations which would fill little space and require little skilled attention already on the market, and effectually cooling to much lower temperatures than are required by an ordinary workroom such places as chocolate factories, indoor markets, etc. Of course it is desirable to reduce the power required for this purpose. This can be largely effected by coating the walls with some non-conductor. Ordinary plaster is a great improvement on bare brick, but better still would be some such lining as steam pipes are covered with, and then a lining of boards. These same linings would proportionally reduce the amount of heating required in winter, but might, perhaps, be found rather costly in many cases. To reduce the losses due to the influx of hot air, the doors and windows should be kept closed as far as possible, and the ventilating air taken in over the cold coils of the refrigerator. Some such arrangement would be a decided boon to the workers, and would in many cases be a source of profit to the employer, as it would increase the quantity and improve the quality of work each individual could do in a given time. F. F.

[NOTE.—In modern workshops the temperature is regulated by the same apparatus, and as a result we can endorse our correspondent's remarks that there is a very appreciable increase of work.—ED.]

Self-Regulating Discharge Battery Switch.—The switch I describe would, I think, be most useful in private plants, when it is not always convenient for the attendant to go to the switch-board to cut another cell into circuit owing to a drop in voltage. The following letters explain the diagram:—*A* is a solenoid shunted from the bus bars with a

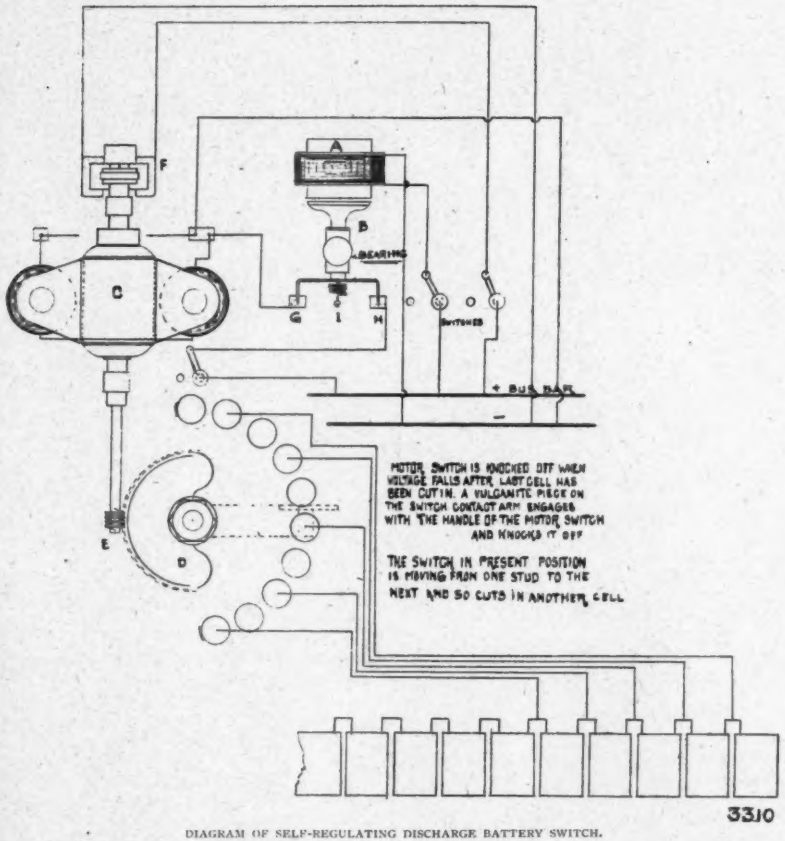

A
B
BEARING
F
C
G
I
H
SWITCHES
+ BUS BAR
−
MOTOR SWITCH IS KNOCKED OFF WHEN VOLTAGE FALLS AFTER LAST CELL HAS BEEN CUT IN. A VULCANITE PIECE ON THE SWITCH CONTACT ARM ENGAGES WITH THE HANDLE OF THE MOTOR SWITCH AND KNOCKS IT OFF
THE SWITCH IN PRESENT POSITION IS MOVING FROM ONE STUD TO THE NEXT AND SO CUTS IN ANOTHER CELL
E
D
3310

DIAGRAM OF SELF-REGULATING DISCHARGE BATTERY SWITCH.

soft iron core through it; *B* an armature, the body of which is made of aluminium (for lightness), with a soft iron plate fixed on top; *C* a small electro-motor; *D* a rack on the switch which gears with the worm *E* on the motor shaft; *F* an electro-magnetic brake, which is always on when discharging; *G* and *H* two mercury cups; *I* a regulating spring. After the regulating spring *I* has been set to allow of the arm falling at a certain drop of voltage, the apparatus can be left to regulate the supply itself. The voltage falling, the arm drops and makes contact with the motor and bus bars. The motor rotates under the load of the brake and the resistance offered by the switch. The motor would never get any time to make a high speed travelling from one stud to another, because as soon as the switch-bar touched the next stud the voltage would jump up again. The induction of the solenoid would be again increased, and it would draw up the arm, breaking contact between the motor and supply. After all the regulating cells had been cut in, the switch-arm would slide on to a dummy contact, and so cut off all supply. The cells would then be quite ready for a new charge. The switch-rack *D* could be thrown out of gear in charging.

J. WM. WARDLE.

Planing a Spiral Surface.—Having to produce a number of 6-in. square bars with spiral faces of one convolution in 8 ft., we adopted the following arrangement for planing the surfaces, as shown at Figs. 1

and 2. The bars, which were 11 ft. long, were roughly turned to the diameter of the diagonal, viz., 8·5 ins., the ends of the bars beyond 8 ft. being turned down to form journals. One of the turned ends was provided with four keyways cut at right angles, and which served to hold pinion *N* in position with key. Two pedestals, *P P*, were bored to suit journals of shaft, and bolted on centre of plainer table. A rack *R* moving in strips, with end constructed as Fig. 3, engaged with the angle bar *Y*, secured at each end to a stationary support. As the table travelled forward, the necessary amount of cross travel was given to the rack, which moved the pinion one revolution. On the completion of each face the pinion was moved to the next keyway. Before commencing the first cut, the bar *Y* was tested to ensure the proper inclination.

H. M. A. AND A. P.

[NOTE.—Where more than a complete convolution is required, bevel wheels at *N* and shaft carrying pinion engaging in rack *parallel* to table could be substituted for rack *R*.—ED.]

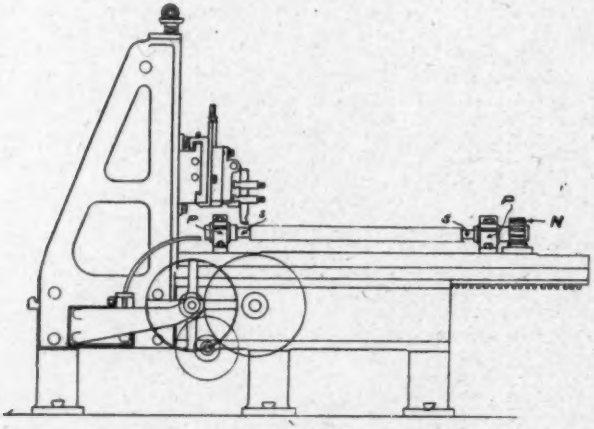


FIG. 1.

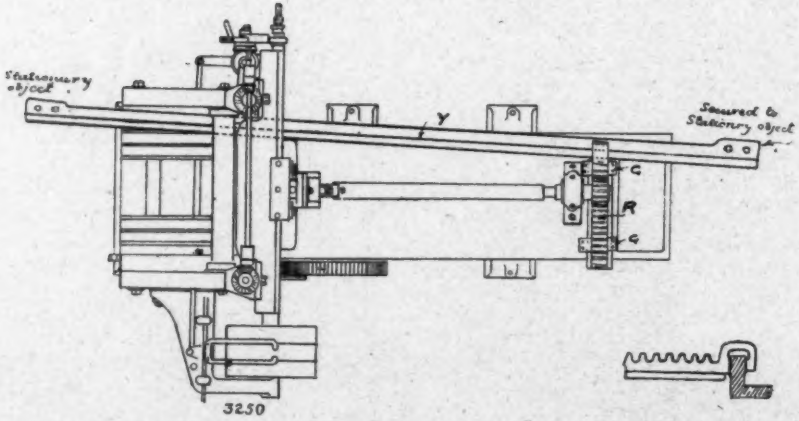


FIG. 2.

PLANING A SPIRAL SURFACE.

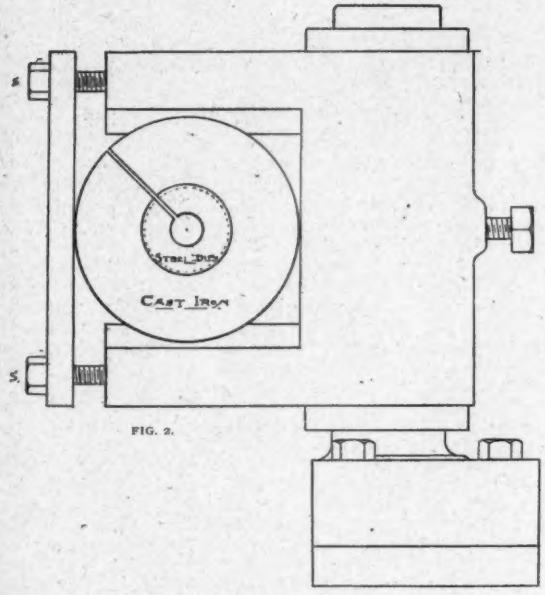


FIG. 2.

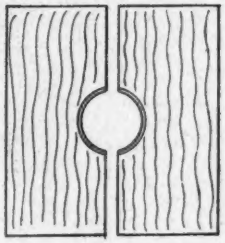


FIG. 1.

ALL-METAL STAY.

Repairing a Collapsed Boiler.—We have a 7 in. by 3 in. circular copper tank for a hot-water circulation, the water being heated by means of a Clutha hot-water heater at the side. During building alterations, we found it necessary to remove the expansion pipe, and plugged up the hole, allowing the water to expand back into the cold-water cistern. One morning, while the cold water supply was off and the cistern empty, someone turned the steam on to the heater, and boiled away most of the water in the tank, with the consequence that when the cold water was turned on again the tank collapsed, owing to the steam condensing and the atmospheric pressure on the outside. It had the appearance of having been crossed several times by a traction engine; the back and front had met, and the top and bottom were within 3 ft. of each other; to look at, it seemed only fit for scrap. As it would have taken some time to procure a new one, and could not very well be done without, we got a hydraulic pump, and started what seemed a hopeless job; but after several hours' pumping and hammering, we got it back to its old shape. Where it showed signs of tearing, we put large patches of solder, and thus prevented the fracture from spreading; and now, after being properly patched, the tank is apparently as good as ever.

J. A. McC.

All-Metal Stay.—The practice of turning and screw-cutting long slender spindles and screws is generally to use a "travelling stay" carrying wood dies, lined in some instances with hoop iron or thin strip of mild steel. This arrangement (shown in Fig. 1) answers well for a time, *i.e.* until the lubricant has permeated the wood dies, and destroyed the fit they originally had in the stay. Now it is absolutely essential to good and true turning, and especially screw-cutting, to have rigidity, or perfect coincidence, between all the fitting parts of the lathe itself in the first place, and next in any appliance used on the lathe. This led the writer to construct a stay similar in design to Fig. 2, shown in detail. The result has been most satisfactory, with the following advantages:—(1) No new dies required; (2) product of a higher state of accuracy; (3) increased amount of work done. The die-holder is made from a ring of cast-iron, which is first bored and turned, and a groove milled or shaped, as shown, to fit the stay. The above die-holder serves for

all dies, since they are all turned to the same dimensions, but with different bores. The original holes in the dies are made most carefully, and rimered to standard sizes. Since the die-holder and the die are both slit, a small amount of tightening up of the set screws *S* and *S* is sufficient to spring them to grip the work with a proper amount of tension. If, instead of the die-holder shown in Fig. 2, a die pattern were made of square shape (similar to wood dies), a considerable pressure on the screws would be necessary to make the die grip the work.

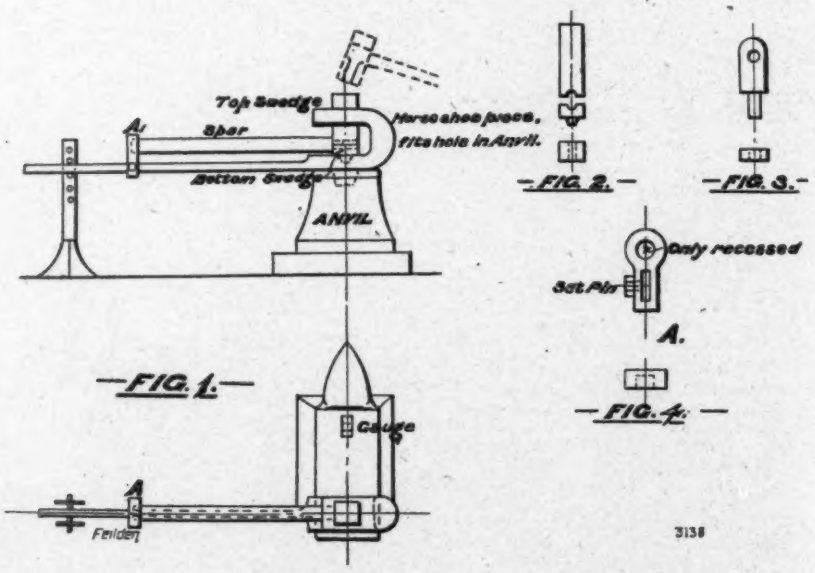
A. P. N.

A Smithing Device.—In the illustrations Figs. 1 to 4, a contrivance is shown for swageing the ends of spars, such as are used for gratings, ladders, &c., in engine-rooms and stoke-holes.

In some shops the necks are formed on the spars or staves in capstan lathes, but where the whole of the work is done by the smith, it is necessary in order to expedite the work and ensure uniformity of length, to adopt the arrangement, as Fig. 1, with the several details shown in position. The method of procedure is as follows:—One end of the spar is heated almost white, placed between the swages, the cold end inserted in the sliding-piece *A*, and by a series of rapid blows, the heated end is reduced to the required diameter. The piece *A* is adjustable on the rod to accommodate any length of spar. The swages are also of different sizes to suit $\frac{7}{8}$-in., $\frac{3}{4}$-in., $\frac{5}{8}$-in. or $\frac{1}{2}$-in. black bars, which are usually reduced to $\frac{1}{8}$-in. below these sizes, this being a sufficient amount to form a good shoulder, an allowance of $\frac{1}{2}$-in. in length more than the thickness of the side pieces will be found ample for riveting over.

BREVI MANN.

[By noting the elongation produced by the swageing process, the whole of the bars could be cropped or sheared off to the exact length.—ED.]



A SMITHING DEVICE.

RECENT AERONAUTIC EXPERIMENTS.

THE increasing interest that has been shown in recent years by engineers in the problems of aerial navigation has been in no small degree responsible for the speculations of the man in the street, who talks glibly of travelling by flying machine in the not far distant future. Fiction has supplied another factor in stimulating such speculation into one of the most fascinating departments of applied mechanics. To those, however, in possession of the natural caution which is associated with scientific habits of thought, and which is so pronounced in those who have had the advantage of an engineering training, investigation of a practical character in aeronautics has acted as a curb on the imagination, and has revealed the difficulties which encircle any such solution of the problem as that imagined by the irresponsible dreamer.

Outside the uses to which ordinary balloon ascents have been put, such as, for example, purposes of observation in military and meteorological matters, in no sense can investigation claim to have set the question even one step nearer the commercial utilisation of aerial machines.

It would be folly to deny, however, that much useful work has very recently been done in the development of the *science* of aeronautics, although, to use the words of Rear-Admiral Melville, "the present development of both the dirigible balloon and the flying machine would seem to be that aerial navigation is merging into an heroic sport."

The successful attempt of M. Santos-Dumont to win the Deutsch prize by the plucky trips undertaken in a dirigible balloon of his own design; the experiments of a less pretentious but none the less interesting character undertaken by Lilienthal, and the more fortunate Chanute and Wilbur Wright in connection with the design and working of aëroplanes, and finally the investigations undertaken by Baden-Powell into the theory and practice of kites, bear ample testimony to the progress that has been made.

By including the name of Maxim and the flying machine proper in the category of investigators, the main avenues along which research is proceeding will be indicated, although the main purpose of this article will be confined to giving some account of the recent efforts of Mr. Wilbur Wright, who, in his study of aëroplanes, has—in the opinion of those who maintain that the real solution of the flying machine will be found in this direction rather than in that of the gas balloon—achieved results of real value.

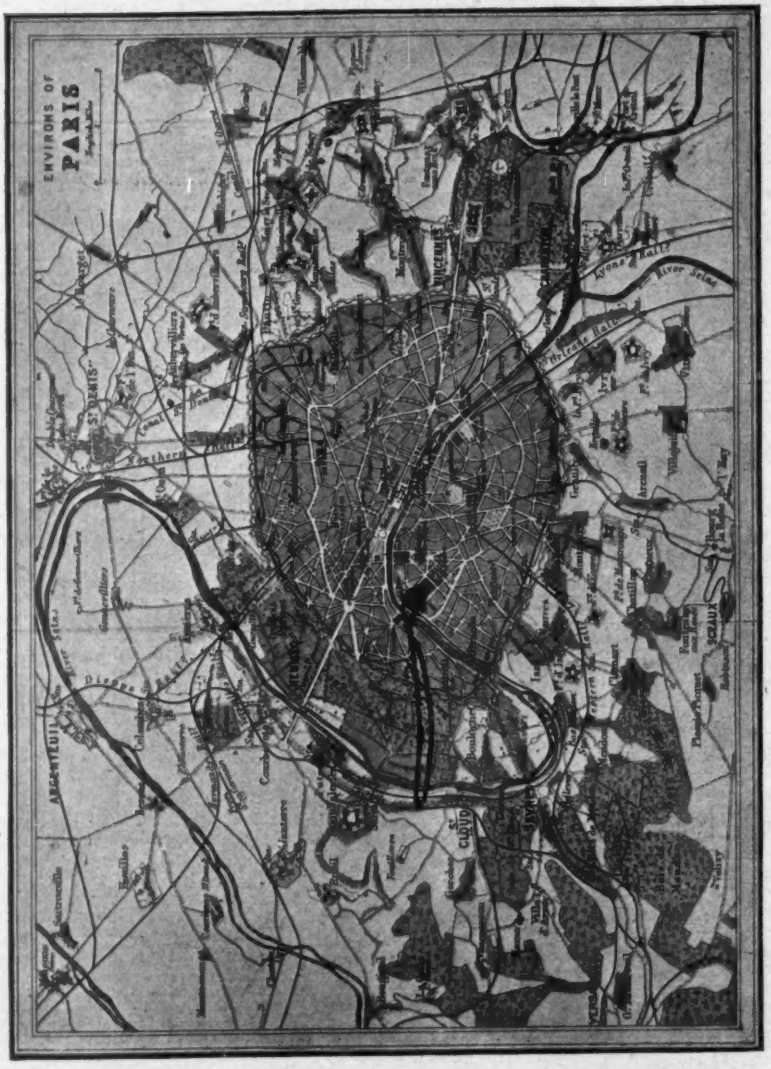
In considering the physical facts connected with artificial flight, there is much to support the case against the gas balloon—in spite of the advantages attendant upon its carrying capacity—viz., that it can never be of commercial utility on account of its resisting qualities failing in anything except normal currents of air.

M. Santos-Dumont, however, has attracted much attention to this phase of the subject by his recent experiments, which, if emphasizing the unsuitability of the gas balloon except in anything like favourable atmospheric conditions, showed, nevertheless, that under those circumstances he had his machine well under control.

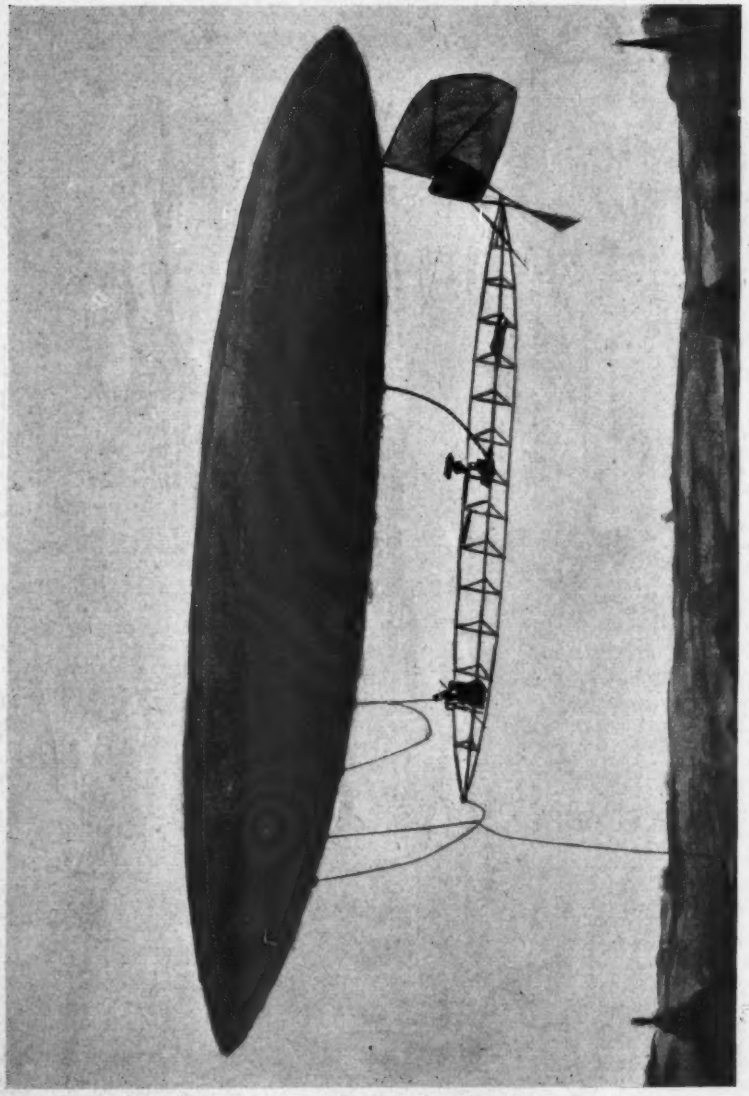
The following are some of the particulars of the now historic No. 6 balloon, in which he made a trip from the Parc d'Aerostation at St. Cloud to the Eiffel Tower and back in 29 minutes 30 seconds.

The balloon took the form of an elongated ellipsoid of 16·7 ft. short and 98·4 long axis, terminating at the two ends in cones 3·28 ft. in height. Its total capacity was 21,925 cubic feet. The material used in the construction was fine white Japanese silk, specially varnished to render it impermeable to gas. It was provided with an interior air-bag occupying at the base and centre of the balloon one-tenth of its volume, and was kept filled automatically by a compression pump driven by the motor. The object of this compensating air-bag was to keep the balloon properly distended, as M. Santos-Dumont had found in former experiments that owing to the differences of temperature met with, and the leakage of the gas, a balloon of an elongated form was in danger of folding in the middle.

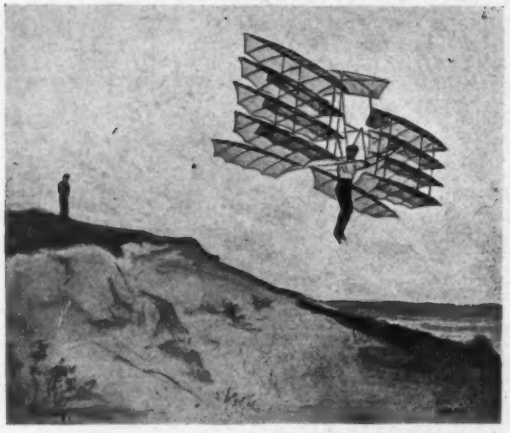
The motive power was supplied by a 20-h.p. Buchet petroleum motor, with four cylinders mounted on an aluminium crank box, the cooling being effected by a circulation of water. The motor was coupled to a propeller composed of two vanes of wood and steel, covered with silk and highly varnished; the spread of the blades being 13 ft. Supporting the motor, fuel reservoir, shaft, and basket car is a framework, built up from a keel consisting of a beam 46 ft. in length this framework being in turn suspended from the balloon by means of steel wires which



MAP SHOWING THE ROUTE TAKEN BY THE SANTOS-DUMONT BALLOON NO. 6. FROM ST. CLOUD TO THE EIFFEL TOWER AND BACK.



GENERAL VIEW OF THE SANTOS-DUMONT BALLOON NO. 6.



CHANUTE'S MULTIPLE WING MACHINE.

were attached to the envelope here and there.

To insure equal tension of these suspenders, and the balloon retaining a horizontal position, the engine and car were placed at opposite ends of the framework. The steering rudder was also of silk, and was fixed between the balloon and the framework immediately over the propeller.

The route taken by this balloon across Paris is shown on the accompanying map.

In the more recent experiments at Monte Carlo, M. Santos-Dumont used a much more powerful balloon, the length of which was 120 ft., and diameter 18 ft. at the middle.

The setting out the path of a balloon has been a matter of no small difficulty, but the occasion of the voyage of M. Santos-Dumont, from St. Cloud to the Champ-de-Mars, was taken advantage of by M. Armengaud to test a graphical method devised by him for the projection, on the surface of the earth, of the path taken by the balloon, an account of which he presented recently in a paper to the French Academy and which was reproduced in a recent issue of *Comptes Rendus*. The main element of the problem is the determination of the velocity of both the balloon and the wind, as the resultant of them gives the apparent velocity of the balloon. Given either the velocity of the balloon or the wind and the actual speed, the remaining factor may be calculated. Furthermore, M. Armengaud shows a method of computing the real velocity of the balloon in these circumstances when the observed velocity equals that of the real; and of the influence of the wind in other circumstances. The data upon which the plotting of the route is based is also given, together with the route itself plotted on a military map of the district.

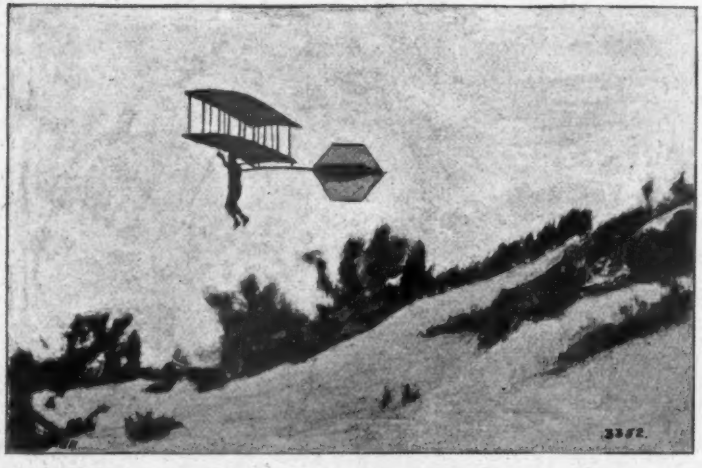
On purely theoretical considerations the balloon Santos-Dumont No. 6, having regard to the velocity of the wind, should have attained a higher actual velocity than it did, although it has been shown, in the *Comptes Rendus*, by M. H. Deslandres, who is also an investigator of the subject, that an advance was actually made when considering the experiments of previous investigators. The maximum speed hitherto obtained by a

LILIENTHAL'S MACHINE.

dirigible balloon was 6·5 mètres (24 ft. 4 ins.) per second, whereas the Santos-Dumont No. 6 approached 8·5 mètres (27 ft. 10 ins.) per second. The difference of 2 mètres per second, which occurred between the calculated and actual speeds, is shown by M. Deslandres to be due to the movement of the balloon in both the *vertical* and horizontal planes—that is to say, a pitching movement which increases with the velocity of the balloon. The speed determinations made by M. Deslandres are in substantial agreement with those made by M. Armengaud, a fact which speaks well for the valuable nature of the contributions of these investigators to the science of aëronautics.

The great obstacle which has militated against the success of dirigible air-ships has been the want of a motor sufficiently light to enable a gas-balloon to sustain its weight and that of the operator with anything like stability, or an aëroplane to sustain the necessary weight at all. It has been recently pointed out by Mr. Chanute, the president of the Western Society of Engineers, that fifteen years ago the lightest steam motor obtainable was the marine engine, in which every horse-power meant 60 lbs. weight, while that of the gas engine was much more. To-day it is possible to build steam motors weighing only 10 lbs. to the horse-power and gas engines 12½ lbs. to 15 lbs. Much of the success attained by M. Santos-Dumont has been due to this fact—the motor first used by him weighed 50 kilogrammes per horse-power, while that being used by him now does not exceed 5 kilogrammes.

When a still lighter motor is available—or, perhaps, when the direct production of electricity from carbon becomes a *fait accompli*—the chief difficulty encountered in the problem of flying through the air may be reckoned to have been solved. There is one other factor, however, and that an equally important one—viz. the question of safety—and while, no doubt, M. Santos-Dumont is doing valuable work in this direction with the gas-balloon, he leaves untouched what may be described as the first principles of aërostation—viz. those governing the flight of birds, kites, and aëroplanes.



CHANUTE'S DOUBLE-DECK MACHINE.

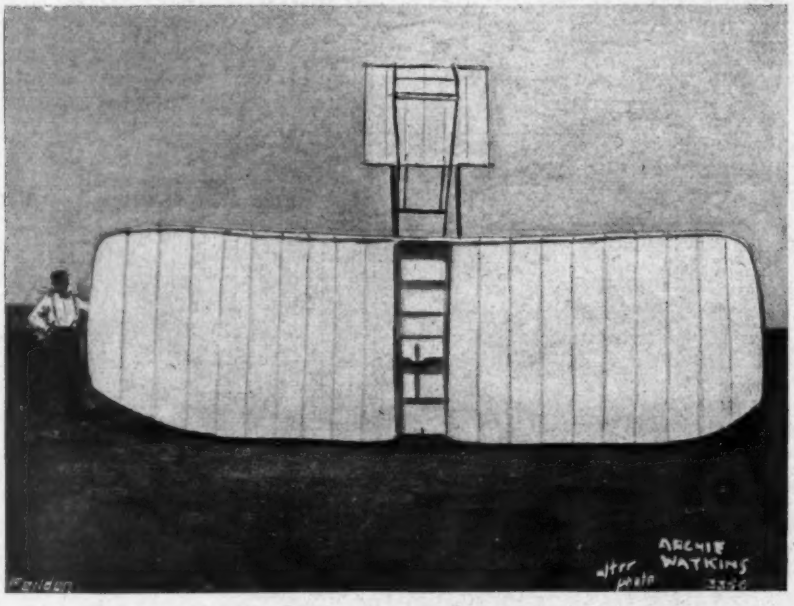
What ultimate shape the developed flying machine will obtain it is impossible to predict, but it is certain that the first principles of flight pure and simple—about which so very little is known up to the present—must play a very important part in its construction. Unfortunately, the investigation of this side of the question is attended with very grave risks to the experimenter; but this has not deterred such men as the late Herr Otto Lilienthal, Mr. Pilcher, and Mr. Chanute from making efforts which, if less pretentious have certainly been as valuable as those of the men who have been working with the gas-balloon.

In these experiments with the aëroplane, none of a more daring character has hitherto

been attempted than those conducted by Mr. Wilbur Wright and his brother, Mr. Orville Wright, of Dayton, Ohio, who have used surfaces very much greater in extent than those which had, until then, been deemed safe. The results obtained were of a very remarkable character, and were set forth at length in a paper read by Mr. Wilbur Wright, before the Western Society of Engineers, in September last, when President Chanute himself occupied the chair. What follows may be taken as the substance of Mr. Wright's remarks before that society.

securely through the air would take a considerable time. The style of speed that men must learn to manage Mr. Wright forcibly illustrated by letting a piece of paper fall after placing it parallel to the ground, its course in falling being characterised by the gyrations it executed. This art of equilibrium the bird had learned thoroughly, although its skill was not apparent to our sight.

Herr Otto Lilienthal was the first man who, in the opinion of Mr. Wright, really comprehended that balancing was the first instead of the last of the great problems



A BOTTOM VIEW OF MR. WILBUR WRIGHT'S MACHINE.

Mr. Wright began by pointing out that the inability to balance and steer flying machines still confronted students, and that when this one feature had been worked out the age of flying machines would have arrived, for all other difficulties were of minor importance.

The person who merely watched the flight of a bird gathered the impression that the bird had nothing to think of but the flapping of its wings. As a matter of fact, that was a very small part of its mental labour. To even mention all the things the bird had constantly to keep in mind in order to fly

in connection with human flight. He began where others left off, and thus saved much money that it had heretofore been customary to spend in building and fitting expensive engines to machines which were uncontrollable when tried. He built a pair of wings of a size suitable to sustain his own weight, and made use of gravity as his motor. This motor not only cost him nothing to begin with, but it required no expensive fuel while in operation, and never had to be sent back to the shop for repairs. It had one serious drawback, however, in that it always insisted on fixing the condi-

tions under which it would work. These were, that the man should first betake himself and machine to the top of a hill and fly with a downward as well as a forward motion. Although Lilienthal must have thought the conditions were rather hard, he nevertheless accepted them till something better should turn up, and in this manner he made some 2,000 flights, in a few cases landing at a point more than 1,000 ft. distant from his place of starting. Lilienthal, in so doing, probably made the greatest contribution to the solution of the flying problem that has ever been made by one man. He demonstrated the feasibility of actual practice in the air, without which success was impossible.

The balancing of a gliding or flying machine was very simple in theory. It merely consisted in causing the centre of pressure to coincide with the centre of gravity. If a wind struck a vertical plane, the pressure on that part to one side of the centre would exactly balance that on the other side, and the part above the centre would balance that below. This point was the centre of pressure. But if the plane were slightly inclined, the pressure on that part nearest the wind was increased, and the pressure on the other part decreased, so that the centre of pressure was then located, not in the centre of the surface, but a little toward the side which was in advance. If the plane were still further inclined the centre of pressure would move still farther forward. And if the wind blew a little to one side, it would also move over as if to meet it. Now, since neither the wind nor the machine for even an instant maintained exactly the same direction and velocity, it was evident that the man who would trace the course of the centre of pressure must be very quick of mind; and he who would attempt to move his body to that spot at every change must be very active indeed. Yet this is what Herr Lilienthal attempted to do, and did do with most remarkable skill, as his 2,000 glides sufficiently attested.

In the machine designed by Mr. Chanute, which was of the multiple-wing type, the tips folded slightly backward under the pressure of the wind gusts, so that the travel of the centre of pressure was thus largely counterbalanced.

The guiding of the machine was done by a slight movement of the operator's body toward the direction in which it was desired that the machine should go. The double-deck machine, built and tried at the same time, marked a very great structural advance, as it was the first time in which the principles of the modern truss bridge were fully applied to flying machine construction.

In the Lilienthal machine the tail, instead of being fixed in one position, was prevented by a stop from folding downward beyond a certain point, but was free to fold upward without any hindrance. In the Chanute machine the tail was at first rigid, but afterwards it was held in place by a spring that allowed it to move slightly either upward or downward with reference to its normal position, thus modifying the action of the wind gusts upon it. The guiding of the machine was effected by slight movements of the operator's body, as in the multiple-wing machines.

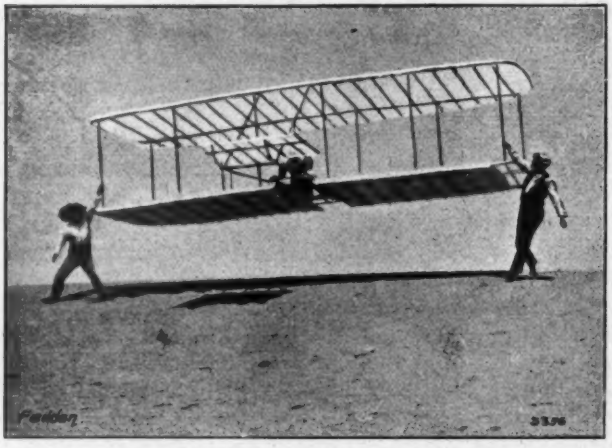
It seemed to Mr. Wright and his brother that the main reason why the problem was not solved, was that no one had been able to obtain any adequate practise. They thought that if some method could be found by which it would be possible to practice by the hour instead of by the second, there would be hope of advancing the solution of a very difficult problem. It seemed feasible to do this by building a machine which would be sustained at a speed of 18 miles per hour, and then finding a locality where winds of this velocity were common. With these conditions, a rope attached to the machine to keep it from floating backward would answer very nearly the same purpose as a propeller driven by a motor, and it would be possible to practise by the hour, and without any serious danger, as it would not be necessary to rise far from the ground and the machine would not have any forward motion at all.

According to the accepted tables of air pressures on curved surfaces, a machine spreading 200 sq. ft. of wing surface would be adequate. When the winds were sufficiently low the plan adopted by Mr. Wright and his brother was to glide from the tops of sand-hills, and when sufficiently strong, to use a rope for a motor and fly over one spot. Tails were dispensed with and a horizontal position for the body adopted in view of minimising the wind resistance, only 1 sq. ft. being thus exposed instead of five, and a half horse-power saved.

The Chanute double-deck system was adopted, consisting of two large surfaces, with a smaller surface placed a short distance in front in such a position that the action of the wind upon it would counterbalance the effect of the travel of the centre pressure on the main surfaces. Thus changes in the direction and velocity of the wind would have little disturbing effect, and the operator would be required to attend only to the steering of the machine, which was to be effected by curving the forward surface up or down. The lateral equilibrium and the steering to right or left were to be attained by a peculiar

torsion of the main surfaces, which was equivalent to presenting one end of the wings at a greater angle than the other. In the main frame a few changes were also made in the details of construction and trussing employed by Mr. Chanute.

A machine of 165 sq. ft. in area was constructed, which, according to the Lilienthal tables, would be supported at an angle of 3 degs. in a wind of about 21 miles per hour. On its being tried as a kite, it was found that while it was supported with a man on it in a wind of about 25 miles, its angle was much nearer 20 degs. than 3 degs. Even in gusts of 30 miles the angle of incidence did not get as low as 3 degs., although the wind at this speed has more than twice the lifting power of a 21-mile wind.



STARTING A FLIGHT.

The system of twisting the surfaces to regulate the lateral balance was tried and found to be much more effective than shifting the operator's body.

Messrs. Wright then turned their attention to making a series of actual measurements of the lift and drift of the machine under various loads, with results which showed that the horizontal pull of the machine, while sustaining a weight of 52 lbs., was only 8·5 lbs., which was less than had been previously estimated for head resistance of the framing alone. It was deficient, however, in lifting power, as compared with the calculated lift of curved surfaces of its size, due, it was supposed, to the curvature of the surfaces being insufficient, it being only 1 in 22, instead of 1 in 12.

A dozen glides were then made with the machine from a sand-hill of 100 ft. in height, and with an inclination of about 10 degs., in a wind of 14 miles per hour. Starting with the aid of two assistants, as shown in the illustration, it was found possible to land while still reclining in a horizontal position upon the machine. Although the landings were made at speeds of more than 20 miles per hour, neither machine nor operator suffered any injury. The slope of the hill was 9·5 degs., or a drop of 1 foot in 6 feet. After attaining a speed of about 25 or 35 miles, with reference to the wind, or 10 to 15 miles over the ground, the machine not only glided parallel to the slope of the hill, but gradually increased its speed, thus indicating its inability to glide on a somewhat less angle than 9·5 degs. The control of the machine proved even better than had been expected, responding equally to the slightest motion of the rudder. With these glides the first series of experiments closed.

The chief conclusions arrived at from the experiments were (1) that a smaller surface set at a negative angle in front of the main bearing surfaces, or wings, would largely counteract the effect of the fore-and-aft travel of the centre of pressure; (2) that steering up and down would be attained with a rudder, without moving the position of the operator's body; (3) that twisting the wings so as to present their ends to the wind at different angles was a more prompt and efficient way of maintaining lateral equilibrium than shifting the body of the operator.

In the next machine,' which was 22 ft. wide, 14 ft. long (including the rudder), and about 6 ft. high, the curvature of the surfaces was increased to 1 in 12, and the area of the machine from 165 sq. ft. to 308 sq. ft., and according to calculations it was reckoned that it would obtain support in a wind of 17 miles per hour with an angle of incidence of 3 degs.

In the first few attempts to glide, in a wind blowing about 13 miles per hour, the machine turned downward and landed after going only a few yards owing to the operator having assumed a position too far in front of the centre of gravity. In the next glide the machine made an undulating flight of 300 ft., during which the full power of the rudder was required to keep the machine from either running into the ground or rising so high as to lose all headway.

In the next glide the machine rose higher and higher, until it lost all headway. This was the position in which Lilienthal had always found difficulty, as his machine then manifested a tendency to make a sudden vertical rush downward.

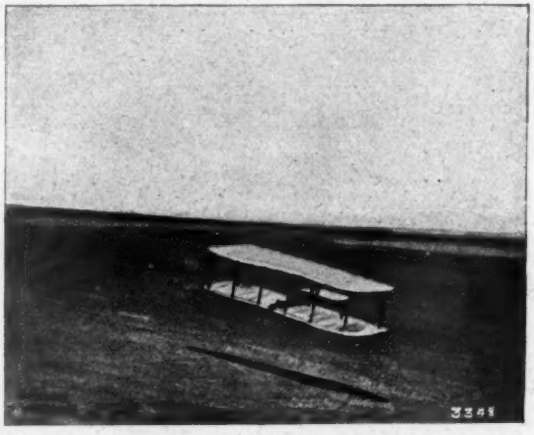
In this case, by turning the rudder to its fullest extent and moving the body slightly forward, the machine settled slowly to the ground, maintaining its horizontal position and landing without injury.

In subsequent flights the same thing occurred, and in one case the machine actually commenced to move backwards, but even then was brought safely to the ground in a horizontal position.

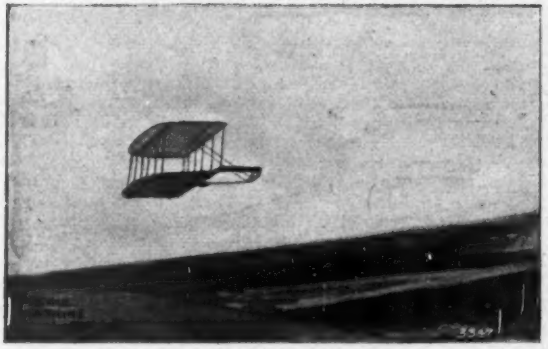
This extrication from difficult positions was due to the use of a front rudder in place of the horizontal tail that had been used by former investigators.

The only question was the difficulty of control experienced in the first few flights, but after some consideration Messrs. Wright concluded that this was due to a reversal of the direction of the travel of the centre of pressure at small angles. In deeply curved surfaces the centre of pressure at 90 degs. is near the centre of the surface, but moves forward as the angle becomes less, till a certain point is reached, varying with the depth of curvature. After this point is passed, the centre of pressure, instead of continuing to move forward, with the decreasing angle, turns and moves rapidly toward the rear. These phenomena are due to the fact that at small angles the wind strikes the forward part of the surface on the *upper* side instead of the lower, and thus this part altogether ceases to lift, instead of being the most effective part of all, as in the case of the plane. Lilienthal had called attention to the danger of using surfaces with a curvature as great as 1 in 8, on account of this action on the upper side. The ribs of the machine were therefore trussed down, so as to reduce the original curvature, and under these new conditions successful glides were made of 366 ft. and 389 ft., in which the machine never failed to promptly respond to even small movements of the rudder, so much so, that the operator could cause it to almost skim the ground, following the undulations of its surface or could cause it to sail out almost on a level with the starting point, and passing high above the foot of the hill, gradually settle down to the ground. Many successful glides were subsequently made in a wind of a velocity of 18 to 22 miles per hour.

It had been the intention of Messrs. Wright, when building the machine, to do the larger part of the experimenting in the following manner. When the wind blew 17 miles an hour, or more, to attach a rope to the machine and let it rise as a kite with the operator upon it. When it should reach a proper height the operator would cast off the rope and glide down to the ground just as from the top of a hill. In this way the trouble of carrying the machine uphill after each glide would be saved. But when they came to try it they found that a wind of 17 miles, as measured by Richard's anemometer, instead of sustaining the machine with its operator, a total weight of 240 lbs., at an angle of incidence of 3 degs., in reality would not sustain the machine alone—100 lbs.—at this angle. Its lifting capacity seemed scarcely one-third of the calculated amount. For a time they were led to suspect that the lift of



A LOW GLIDE.



A HIGH GLIDE.

curved surfaces little exceeded that of planes of the same size; but further investigation and experiment led Messrs. Wright to the opinion that (1) the anemometer used over-recorded the true velocity of the wind by nearly 15 per cent.; (2) that the well-known Smeaton co-efficient of ·005 V^2 for the wind pressure at 90 degs. was probably too great by at least 20 per cent.; (3) that Lilienthal's estimate that the pressure on a curved surface having an angle of incidence of 3 degs. equals ·545 of the pressure at 90 degs. was too large, being nearly 50 per cent. greater than very recent experiments made by themselves with a special pressure testing machine; (4) that super-position of the surfaces somewhat reduced the lift per square foot as compared with a single surface of equal area.

Many experiments were performed in measuring the horizontal pressure on the unloaded machine at various angles of incidence. It was found that at 13 degs. the horizontal pressure was about 23 lbs. This included not only the drift proper, or horizontal component of the pressure on the side of the surface, but also the head resistance of the framing as well. The weight of the machine was 108 lbs.

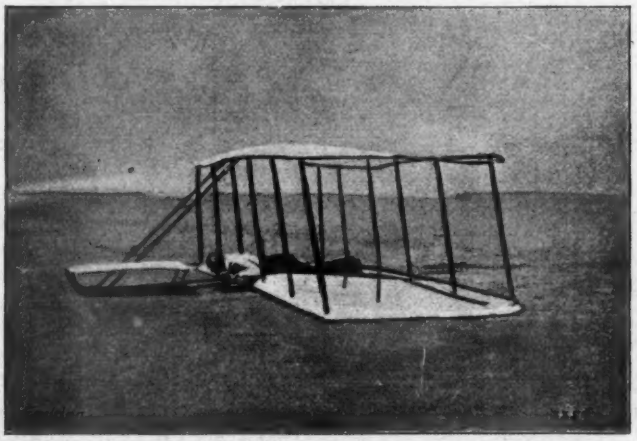
If the pressure had been normal to the chord of the surface, the drift proper would have been to the lift (108 lbs.) as the sine of 13 degs. is to the cosine of 13 degs. or $\frac{\cdot 22 \times 108}{\cdot 97} = 24$ lbs., but this slightly exceeded the total pull of 23 lbs. The conclusion reached by Messrs. Wright, therefore, was that the average pressure on the surface, instead of being normal to the chord, was so far inclined toward the front that all head resistance of framing and wires used in the construction was more than overcome. In a wind of 14 miles per hour resistance was not a negligible factor so that the tangential force was one of considerable value.

In a higher wind, which sustained the machine at an angle of 10 degs., the pull on the scales was 18 lbs. With the pressure normal to the chord, the drift proper would have been $\frac{\cdot 17 \times 98}{\cdot 98} = 17$ lbs., so that although the higher wind velocity must have caused an increase in the head resistance, the tangential force still came within 1 lb. of overcoming it.

A series of experiments was also undertaken by Messrs. Wright to accurately determine the amount and direction of the pressure produced on curved surfaces when acted upon by winds at the various angles from zero to 90 degs., and although they are not yet concluded, in general they support Lilienthal in the claim that the curves give pressures more favourable in amount and direction than planes. They were unable to obtain direct measurements of the horizontal pressures of the machine with the operator on board, but by comparing the distance travelled in gliding with the vertical fall, it was easily calculated that at a speed of 24 miles per hour the total horizontal resistances of the machine, when bearing the operator, amounted to 40 lbs., which is equivalent to about 2¼ h.p. It must not be supposed, however, that a motor developing this power would be sufficient to drive a man-bearing machine. The extra weight of the motor would require either a larger machine, higher speed, or a greater angle of incidence, in order to support it, and therefore more power. Mr. Wright considered it probable, however, that an engine of 6 h.p., weighing 100 lbs., would answer the purpose, and that such an engine was entirely practicable. Working motors of one-half this weight per horse-power (9 lbs. per horse-power) have been constructed by several different builders. Increasing the speed of the machine from 24 to 33 miles per hour reduced the total horizontal pressure from 40 to about 35 lbs. This was quite an advantage in gliding as it made it possible to sail about 15 per cent. further with a given drop. However, it would be of little or no advantage in reducing the size of the motor in a power-driven machine, because the lessened thrust would be counterbalanced by the increased speed

per minute. Some years ago Prof. Langley called attention to the great economy of thrust which might be obtained by using very high speeds, and from this many were led to suppose that high speed was essential to success in a motor-driven machine. But the economy to which Prof. Langley called attention was in foot-lbs. per mile of travel, not in foot-lbs. per minute. It was the foot-lbs. per minute that fixed the size of the motor. The probability was that the first flying machines would have a relatively low speed, perhaps not much exceeding 20 miles per hour, but the problem of increasing the speed would be much simpler in some respects than that of increasing the speed of a steamboat; for whereas in the latter case the size of the engine would have to increase as the cube of the speed, in the flying machine, until extremely high speeds were reached, the capacity of the motor increased in less than simple ratio; and there was even a decrease in the fuel consumption per mile of travel. In other words, to double the speed of a steamship or of a balloon type of airship, eight times the engine and boiler capacity would be required, and four times the fuel consumption per mile of travel; while a flying machine would require engines of less than double the size, and there would be an actual decrease in the fuel consumption per mile of travel. Conversely, the disadvantage of the flying machine was apparent; for in the latter no flight was possible unless the proportion of horse-power to flying capacity was very high, but a steamship was a mechanical success if its ratio of horse-power to tonnage was insignificant. A flying machine that would fly at a speed of 50 miles an hour with engines of 1,000 h.p. would not be upheld by its wings at all at a speed of less than 25 miles an hour, and nothing less than 500 h.p. could drive it at this speed. But a boat which could make 40 miles per hour, with engines at 1,000 h.p., would still move 4 miles an hour, even if the engines were reduced to 1 h.p.

There was another way of flying which required no artificial motor, and many workers believed that success would first come by this road. Mr. Wright referred to the soaring flight, by which the machine was permanently sustained in the air by the same means that are employed by soaring birds. They spread their wings to the wind, and sailed by the hour, with no perceptible exertion beyond that required to balance and steer themselves. What sustained them was not definitely known, though it was almost certain that it was a rising current of air. But whether it were a rising current or something else, it was as well able to support a flying machine as a bird, if man once learnt the art of utilising it. In gliding experiments it had long been known that the rate of vertical descent was very much retarded and the duration of the flight greatly prolonged, if a strong wind blew *up* the face of the hill parallel to its surface. The machine, when gliding in still air, had a rate of vertical descent of nearly 6 ft. per second, while in a wind blowing 26 miles per hour up a steep hill, glides were made in which the rate of descent was less than 2 ft. per second. And during the larger part of this time, while the machine remained exactly in the rising current there was no descent at all, but even a slight rise, and if the operator had had sufficient skill to keep himself from passing beyond the rising current, he would have been sustained indefinitely at a higher point than that from which he started.



LANDING.

The conclusions reached from the whole series of these important experiments may be briefly summarised as follows :—

1. That the lifting power of a large machine, held stationary in a wind at a small distance from the earth, is much less than the Lilienthal table led them to expect. When the machine was moved through the air, as in gliding, the discrepancy seemed much less marked.

2. That the ratio of drift to lift in well-shaped surfaces was less at angles of incidence of 5 degs. to 12 degs. than at an angle of 3degs.

3. That in arched surfaces the centre of pressure at 90 degs. is near the centre of the surface, but moves slowly forward as the angle becomes less, till a critical angle varying with the shape and depth of the curve was reached, after which it moved rapidly toward the rear till the angle of no lift was found.

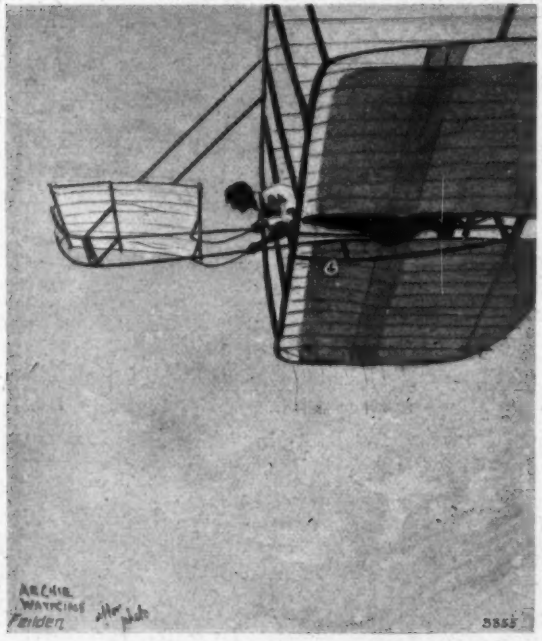
4. That with similar conditions, large surfaces could be controlled with not much greater difficulty than the small ones, if the control was effected by manipulation of the surfaces themselves, rather than by a movement of the body of the operator.

5. That the head resistances of the framing could be brought to a point much below that usually estimated as necessary.

6. That tails, both vertical and horizontal, might with safety be eliminated in gliding and other flying experiments.

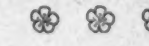
7. That a horizontal position of the operator's body might be assumed without excessive danger, and thus the head resistance reduced to about one-fifth that of the upright position.

8. That a pair of superposed, or tandem surfaces, had less lift in proportion to drift than either surface separately, even after making allowance for weight and head resistance of the connections.



SOARING.

In looking carefully into the investigations of Mr. William Wright and his brother, no choice is left except to pass the highest commendations upon the valuable work done and the results achieved by them. Unlike those who have made so many attempts to solve the problem by attempting everything at once, that is, to design a complete machine for navigating the air, they have wisely confined their efforts to an investigation of first principles; and there would appear to be no valid reason against the presumption that the practice of slow gliding on Messrs. Wright's plan will prove to be the means by which our knowledge of the air currents which enable soaring birds to transport themselves to any desired point by first rising in a circle, and then sailing off at a descending angle, will be largely extended and utilised.



INDUSTRIAL PROGRESS

ENGINEERING NOTES AND COMMERCIAL INFORMATION

FROM ALL SOURCES.

American Methods in Steel Construction.—At a recent meeting of the Institution of Civil Engineers a paper was read on the above-mentioned subject by H. B. Molesworth, M.Inst.C.E. The author, in noticing the fact that many recent contracts for steelwork had been secured by American manufacturers in competition with English firms, suggested that a description of American methods would be advantageous. The quality of American first-class work was excellent in design, material, workmanship, and finish, and was fully equal to English work. The cost of labour, though higher as regarded the amount earned by individual workmen, was lower than in England, when the quantity of work turned out was taken into account. English bridge-works were frequently cramped for room, and hampered with old-fashioned and obsolete machinery, while American works were kept up to modern requirements, and obsolete machinery was turned out as soon as it was superseded by anything more efficient. Works in America usually ran night and day, and American workmen took fewer holidays than English workmen. The author confined his description to the bridge department of the Pencoyd Works of the American Bridge Company, near Philadelphia; and after giving a general description of the works, traced the material from the bridge-shop yard through the various processes into the loading-up yard, whence it was shipped. The bridge-shop was electrically driven, the cranes and larger machines having each its independent motor. The material was moved longitudinally through the shop on trollies and transversely by electric cranes; the shop was roofed in, and the floor was boarded. The material rested almost entirely on skids, and every process moved it farther along the shop, till the finished work emerged at the opposite end to that at which the steel entered. The output in gross tons per man per annum averaged — draftsmen, 771; bridge-shop, 115; forge, 45; eye-bars, 185; templaters, 2,366. The steel was open-hearth steel, rather softer than was generally used in England, of excellent quality, and giving very uniform tests. The greatest care was taken to deliver all material into the bridge-shop yard perfectly straightened. The drawings were prepared in a very complete manner, and gave much more information than was usually furnished on drawing in England. Great care was taken to minimise smith's work, and to duplicate as many parts as possible. Stops, guides, automatic spacing punches, and multiple punches were largely used. The angle-shear was used much more than in England, and joists of the largest size were sheared at one cut without any distortion; punches and dies were all made on automatic lathes, and were interchangeable. All the larger shearing machines were mounted on turntables. Plates were handled under punches by roller frames or goose-necks, and moved by a chisel bar working on a fulcrum. Rimering was done by gantry drills, which resembled a Wellington crane with eight radial drills on it. Pneumatic drills and riveters and chipping machines of the Boyer type were much used, and bad holes, which were very uncommon, were rimered and not drifted. Ends of long pieces were rimered or drilled by compressed-air drills, fed up to the work by a compressed-air cylinder behind them. Large plate girders were riveted by hydraulic gap riveters mounted on a ram to raise or lower them, the work being suspended from an electric Wellington crane traversed by a switch on the riveter platform. Ends of members were milled by rotary planers, which had heads 4 ft. 6 ins. to 6 ft. in diameter, with cutters fixed near the periphery. Angle stiffeners were bevelled in pairs in a milling machine with fast vertical feed, and fitted perfectly. Large joints or channels were handled with clip-hooks furnished with chisel points. Very little planing was done in the works. "Universal" plates were used, and were rolled by nearly all American plate mills without extra charge. The responsibility for the small output per man in England rested only partially with the manufacturer, who was hampered in every effort to introduce improvements by the action of the workmen. The author suggested improvements on the following lines:—(*a*) A careful arrangement of works to avoid unnecessary handling, and give ample facilities for such as was necessary; (*b*) more complete drawings; (*c*) the condemnation and removal of obsolete machinery and the proper maintenance of what was in use; (*d*) ample motive-power; (*e*) the more extended use of stops, guides, and multiple and spacing punches.

Healthiness of Gas-Lighting.—In a recent communication to us, Mr. Edward A. Harman, M.Inst.C.E., points out that a common outcry and complaint against gas is that sometimes a slight sulphurous odour can be detected, though the quantity is very small. Considering the exten-

sive adoption of the medical sulphur treatments all over the world in cases of consumption and other lung affections, one cannot conceive that a small quantity of sulphur is injurious; indeed, on the contrary, it is strange if it is not even beneficial to health. Mr. Harman remembers travelling in a train with a gentleman of extended experience, and when about to go through a tunnel he proceeded to close the window, but his experienced friend objected, remarking that he always preferred to travel through a tunnel with the windows open, so as to get the full benefit derivable from the sulphur. He attributed his strong lungs and the splendid condition of his chest to this habit, which he insisted was a most beneficial one, particularly in his case where he had heavy duty as a vocalist. He also gave it as his opinion that there would be fewer cases of weak lungs, and even fevers, if more sulphur were freely inhaled. Mr. Harman cites another and similar case. A medical gentleman travelling between Yorkshire and London was astounded to see a mother holding her baby at the open carriage window when passing through a tunnel, and in his amazement inquired the reason for this apparently insane proceeding. Her reply was that the child suffered from croup, and the doctor had recommended it "Tunnel Air." It is a common practice in districts where asthma and bronchitis are prevalent, for people to purchase at the Gas Works a small quantity of tar, which is put into a gallipot, jar, or other vessel, and placed under the bed, the experience being that gases emanating therefrom have a soothing effect upon the lungs. It is well known that gasworks are regarded as first-class health resorts for children suffering from whooping cough. Mr. Harman remembers many children troubled with this plague being brought to gasworks and being carried or walked about for an hour or more around the opened purifier boxes, tar syphons, etc. The more sulphurous and ammoniacal the smells were, the greater the relief the children obtained. One would think from the popular objections that the least trace of sulphur in the gas, instead of being beneficial to health, was harmful. It is a fact that the action of sulphur upon disease germs is fatal to them, as demonstrated when sulphur is used as a disinfectant. Sometimes, in entering a room which is electrically illuminated, it is found the air is heavily charged with carbonic acid of which the occupants are oblivious, the complaints of headaches and depression being attributed to any other cause than the right one. The same conditions prevail frequently in churches, chapels, and large public buildings lighted by electricity, where the audience are simply sitting in an atmosphere surcharged with carbonic acid, due to the fact that the electric lamps do not emit sufficient heat to promote ventilation. Other more discreet and sagacious managers have tried to provide against this lack of ventilation by placing gas burners in the roof, and thereby creating an upward draught independent of the lighting arrangements. Considering how largely in demand both sulphur and ammonia salts are, how passing strange it is that complaints should be made that the consumption of gas is detrimental to health, if not even poisonous, when undoubtedly the very thing objected to is a positive physical stimulant and health preservative!

Facing Steel or Iron Sledges with Copper.—The facing of hammers or sledges with copper so as to soften the blow and prevent injury to the metal under operation, is becoming more and more customary. Under these circumstances, the description of an efficient method recently patented by Messrs. Comley, of Braddock, Pennsylvania, U.S.A., may not be without interest to our readers. It is essential, say the patentees, that the iron or steel before welding the copper or brass should be thoroughly freed from scale or rust, which may be done by any method in practice. The body portion of hammer or other tool to be united to the copper face being placed in a receptacle, such as a black-lead crucible, in which it may be subjected to the temperature of the fire or furnace, the body being properly covered to prevent the iron or steel from oxidizing. The receptacle or crucible is heated until the temperature of the iron or steel body is raised to nearly the melting-point of the copper. At the same time a sufficient quantity of copper is placed in a vessel or crucible in the fire or furnace and melted. While in the molten state the scum or impurities are gathered. The copper being melted and the hammer body being now ready to be united, the two receptacles or crucibles are taken from the furnace and the hammer-body is quickly removed from its inclosure, and that part which is to be welded to the copper is immediately plunged into or immersed in the molten copper. A small portion of lead sufficient to cause the copper to solidify is dropped into the crucible, or the lead may first be melted and poured into the vessel containing the molten copper, usually about one-fourth of an ounce of lead to one pound of copper. By putting this quantity of lead into the vessel after the hammer is placed in the molten copper the volatilization of the lead frees any sulphurous-acid gas from the copper, and the copper is purified and solidified. Charcoal and sand or other heat-retaining medium may then be placed over the welded mass, so as to prevent too sudden cooling and allow the molecules of the two metals to unite more firmly. Thus covered, the welded copper-faced body is allowed to gradually cool. As soon as the copper is solidified and cooled to the desired temperature the welded compound body may be removed from the crucible and at once rolled or shaped into any form or may be stacked for further treatment. In making a brass or bronze face weld an alloy is prepared, which may consist of two parts tin, one part zinc, one part lead, and from two to fourteen ounces of copper. The zinc, lead, and tin, melted and alloyed, are poured into the receptacle immediately after the hammer-body is placed in the molten copper, and the whole may then be covered up with charcoal and sand or other heat-retaining medium. In preparing the body portion of the hammer for welding to the copper face, the part to which the copper is to be welded is nicked or roughened, so as to provide an irregular surface

which will give the molecules of the copper and steel a better opportunity to lock and unite, similar to the welding of two pieces of iron at the blacksmith's forge.

Institution of Engineers and Shipbuilders.—At the fifth meeting of the 45th session of the Institution of Engineers and Shipbuilders in Scotland, Mr. William Foulis, president, in the chair, Mr. J. Foster King read a paper on "Rudders," dealing with the rudders of ordinary vessels, to the exclusion of rare types. It might, he said, be expected that the gradual evolution of the tramp steamer, and the accumulated experience of hundreds of vessels of varying types would have produced a generally similar and presumably best form of rudder for each type, but, on the contrary, the most striking feature of the subject was the diversity of opinion expressed in the forms of rudder which were fitted in vessels of the same type, and the small effect of difference in type of vessel upon individual design. Mr. King afterwards, by means of diagrams, showed the evolution of the single-plate rudder, the variations in modern rudder making, and the different parts of rudders in detail, explaining the effects of stress and wear on each style and part. The discussion which followed was taken part in by Mr. James Hamilton, Mr. Scott Younger, Mr. J. Reid, and Mr. MacNicol. Afterwards Mr. F. J. Rowan read a paper on "Producer Gas and its Use in Engineering and Shipbuilding." Producer gas, he said, was the generic name for the product of what might be called the comparatively slow resolution of solid fuel by means of heat, in apparatus of a variety of designs. As distinguished from the ordinary system of gas-making practised in gas-works, where the heat, applied to the exterior of the retorts for the distillation of the coal contained in them, was obtained from coke or other fuel distinct from the charge of coal which was being distilled (although the coke might be the product of coal previously distilled), in the producer system the heat was obtained in the interior of the producer, by the combustion there of the solid portion of the charge of fuel which was being gasified. Since the introduction of gas producers by Bischof in 1839 and Ebelmen in 1840 they had been used in a variety of forms. Within the past 20 years great advances had been made, and what was in 1880 a good producer was perfectly impossible now. The days of the open grate producer like that of Siemens, and of the closed hearth like that of Wilson, were numbered, and such types were being abandoned for producers with water bottoms. These Mr. Rowan divided into two classes (1) those which send the blast among the fuel in a lateral or radial direction, and (2) those which do so vertically. After speaking in detail on each class, Mr. Rowan referred to "Furnaces," advocating the use of gas fuel; and to "Power," remarking that since large power gas engines have been successfully made the field has become vastly wider, and the employment of producers using bituminous coal slack, combined with appliances for the removal of tar and dust from the gases, and in some cases with plant for the recovery of ammonia as sulphate from the nitrogen of the coal, has become an accomplished fact.

Laying Pipes under Water.—The problem of laying pipes under water in the most efficient and at the same time economical manner still awaits solution. Meanwhile, since actual experience is the most reliable source from which to obtain hints for evolving a satisfactory system, digests of attempts made, whether successful or unsuccessful, remain of paramount interest. For this reason we appropriate from our contemporary the *Journal of Gas Lighting* a description of work of this nature carried out recently at Boston, Mass., U.S.A. Two lines of 36-in. cast-iron pipes 1⅛ in. thick laid under the Mistic—a tidal river 1,100 ft. wide at high water—were lowered into their places in sections of 70 or 80 ft. each, this length being made up of six pipes. Three separate kinds of joint were used. Where flexibility was necessary, a spherical turned surface on the spigot had lead run between it and the approximately similarly shaped bell. These allowed a deflection of 1 in 10 in any direction. An ordinary leaded joint could be used for all the other pipes, except at the ends of sections, where a taper turned spigot was put into the last bell before it was lowered, and lead run round. The spigot was then drawn out, and formed the first pipe of the next section. When a section was being lowered, it was supported by a girder-like truss, having fixed to its near end a hydraulic cylinder with an iron rod and hook attached to the piston, by means of which the spigot end of the new section was dragged into the bell end of the last. This was a rather expensive process, and it was found that the total cost was twice that of the pipes—a diver being necessary both for directing and caulking.—A more useful method was one adopted at the Chelsea Creek crossing. Here the stream was tidal, 1,450 ft. wide at high, and 600 ft. wide at low water; the maximum depth in the latter condition of the river being 25 ft. There was a good deal of navigation, with which, of course, the works could not be permitted to interfere. In this case, all the joints were alike—ball and socket leaded joints, similar to those used on the Mistic; and they allowed a maximum deflection of 1 in 6. They were laid continuously in a previously ridged trench, down an 80-ft. radius curved slide suspended from the side of a large scow. This slide was 75 ft. long, and its shoe was adjusted to the bottom of the trench by the smaller of two derricks on the scow. The larger derrick supported the body of the slide and its load of pipes. The shoe end was lowered with its load where the channel crossing began, or where at low water the end of the pipes would be exposed. The scow was warped on 12 ft., allowing the pipes to slide so far down the cradle. Another pipe could then be inserted and leaded on the cradle above water, after which the scow was warped a further pipe-length.

Coal and Iron in the Dominion.—The data published by Mr. Johnson, the Dominion statistician, relating to Canada's iron and coal supply, will be read with great interest in the "Mother-country," for they are full of hope and promise. "The coal area," says the official above mentioned, "is estimated at 97,200 square miles, not including areas in the far North, known but as yet undeveloped. Those areas are included in the political division of Nova Scotia, New Brunswick, the North-West Territories, and British Columbia—about 20 per cent. in the Maritime Provinces of the East, 67 per cent. in the North-West Territories, and 13 per cent. in British Columbia. The development is satisfactory. The percentage of increase in tons of output in the States from 1888 to 1900 was for bituminous 43 per cent., and in Canada for the same period 104 per cent. The position of the coal areas of Canada are exceptionally commanding. The extreme Eastern and Western fields are on the salt water coast line. The Provinces of Quebec and Ontario, without coal, are compensated by the possession of innumerable waterfalls, widely scattered, and with a combined, energy equal to many millions of horse-power, capable of being applied directly or for the cheap production of electricity as a motive force. Canada, throughout a very large part of her territory (more than 3,600,000 square miles) is rich in iron ores of almost every variety known to metallurgy. In Nova Scotia there are extensive deposits of brown hematite, magnetic and spathic ores lying side by side with coalfields of great magnitude. In New Brunswick bog and magnetic ores abound. In Quebec the bog and lake ores are probably the most extensive deposits of like nature in the world. There are also large deposits of chromic iron in Quebec. Ores of iron are widely distributed throughout Ontario, large deposits of hematite and magnetite having been found. In British Columbia magnetite is the chief ore. The ore bed at Texeda Island is from 20 ft. to 25 ft. thick, and assays 68·4 per cent. of iron. The development in the requirements of iron and steel goods is great. In 1894 the country imported in various forms and conditions of manufacture 604,000 tons of iron and steel goods; in 1899 the quantity imported was 812,000 tons, with about the same proportions of highly developed forms of manufacture. In 1894 the production of pig-iron in Canada amounted to 44,791 gross tons, and in 1899 to 94,077 tons, of which 17,796 tons were charcoal and 76,281 tons were charcoal and coke mixed and coke pig-iron.

Mineral Oil as Fuel.—The owners of oil-producing land, or shares in a company possessing such property, will see from the facts stated below that neither electricity nor incandescent gas light is likely to reduce them to beggary. On the contrary, petroleum is entering upon a new road of triumph, and will almost certainly hold an important place among the fuel of the future. Recently its advantages over coal were demonstrated by the *Trocas* on the Tyne and by the *Clam* on the Thames. All those invited by the Shell Transport and Trading Company to witness these runs were most favourably impressed. The Hamburg-American Steamship Company's liner, the ss. *Ferdinand Lereics*, affords another instance of the advantages of oil fuel. The liner travelled from Hamburg to Suez at 11 knots per hour on a fuel consumption of 33 tons of oil, as compared with the previous speed of 10¼ knots on 48 tons of coal for the same journey. The latest contribution to the literature of liquid fuel is made by the "Moniteur des Intérêts Petroliferes Romains," which gives a description of the tests made and results obtained with liquid fuel on board the ss. *King Charles I.* The boat maintains a fast mail service between Constantza and Constantinople. At first one boiler only was fitted with the required apparatus and experimented with during six weeks; 280 tons of residuals stored in the water ballast tanks were raised to the elevated tanks above the boiler by means of a Worthington pump, whence it flowed to the injectors by gravitation. The company was convinced by the excellent results during this experimental stage, which demonstrated fully the facility of maintaining in the boiler the required pressure, the cleanliness, economy in fuel consumption and in the working staff below decks, absence of slag or ashes, and a perfect combustion, the smoke issuing from the funnels being almost imperceptible. Since then the vessel has been entirely re-fitted and has made several regular runs entirely on liquid fuel. Instead of the former 18 overworked stokers there are now only six attendants in the stokehold, and these have comparatively easy work. Instead of the former fuel consumption of 150 tons of Westphalian coal on a run from Constantza and back, only 70–80 tons of residuals are required, and calculating the average price of residuals at 40 francs per ton, the company expects to effect a saving of 100,000 francs per annum on this item of expenditure alone.

Water-supply Problems.—In the course of his inaugural address to the Society of Engineers the President, Mr. Percy Griffith, dealt with some of the broadest aspects of the question of water supply in this country, pointing out that even at the present time there were many towns and districts without any public supply whatever, and others in which the supply was deficient. The causes of this state of affairs were then indicated as being the very imperfect system of control and allotment of responsibility, the irregular and haphazard selection of areas of supply, the peculiar physical characteristics of the country generally, and the present system for allocating the various available sources of supply. He then pointed out the unsatisfactory effects of the rivalry existing in many places between local authorities and water companies, and suggested some limit being placed on the power of the former to interfere with or oppose the latter. The concentration of the population in the large cities, and the consequent increase in the demand for water in such cases, and the growing practice of seeking new sources at long distances from the area to be supplied were

then remarked upon. After pointing out a few elements of risk connected with long conduits, Mr. Griffith suggested that local sources of supply should in every case be developed to their utmost capacity before large gravitation schemes were undertaken. The difficulties attaching to underground sources were then referred to, the condition of the water supply in the county of Essex being quoted as an illustration. As representing modern practice in regard to deep borings, descriptions were given of the boring recently completed at Gainsborough, which was the largest in the kingdom, and that recently commenced at Lincoln, which was intended to be 700 ft. deeper, both under the supervision of the president. Attention was called to the modern practice of dispensing with wells and pumping direct from borings, and to the necessity for special attention being given to the design of the pumping machinery in such cases, an illustration being given from actual practice. The President dealt with the newly-imported American system of lifting water by compressed air, and pointing out its advantages and disadvantages, expressing his opinion that the system was not applicable to any cases where the ordinary form of pump could be used.

The Manipulation of Tool Steel.—In a very interesting paper read before the Railroad Master Blacksmiths' Convention at Denver, Col., U.S.A., Mr. H. W. Rushmer gives valuable information, based on actual experience, regarding the forging and general treatment of alloyed steel for tools, such as the famous Taylor-White steel. He introduces his remarks by the statement that he has frequently seen alloyed steel manipulated in so careless and irrational a manner that if any steel-maker were to treat ordinary steel the same way he would not be able to produce a single perfect bar in a lifetime. He then recommends that ample time should be given to the tool steel to become thoroughly and uniformly treated, and deprecates all attempts to forge the ingots down to the finished bar in a couple of heats as he would the carbon steel. Experience shows that we ought to use the blast sparingly and heat uniformly and thoroughly, bearing in mind that quick and uneven heating is productive of strains. The steel should be heated until it is perfectly plastic and malleable, and all the forgings should be done between the range of a bright-orange and orange colour. It will be noticed that one of the peculiar properties of this steel is, that it chills down much quicker than carbon steel. The very hardest steel, if not hard enough to cut the material, can be heated to a good orange colour and quenched in the blast; and in the absence of this, oil can be used for the quenching. On those steels which are medium hard, the blast, the oil, or hot tin or lead can be employed. The tin or lead is just brought to the melting-point, and the tools are partly chilled in this and then taken out and placed in the oil or blast. The mildest steel cannot be quenched in the blast, and must be tempered in the oil and water. When tempered in the water, they are heated carefully; the cutting points are dipped in the water, drawn to the straw colour, and then placed in the oil, so as to prevent the temper from running. A good annealing will place the steel in such a condition that it can be tempered in water, which gives it great endurance.

Electric Furnaces for Glass Production.—The art of glass-making has seen many more or less ephemeral innovations of recent years, especially as regards the apparatus and the methods used for fusing the mixture of silica and alkalies. The pot furnace, in which clay pots are placed into a furnace, and exposed externally to the heat of a contiguous grate, gave gradually way to the "tank" furnace, in which the glass is fused in great quantities upon the hearth of a reverberatory furnace. Thus direct firing superseded gas firing, both regenerative and recuperative systems being employed; and now the electric furnace appears upon the horizon, championed by Dr. Bermbach, who in the *Elektrochemische Zeitschrift* describes the method of arranging a furnace for the employment of electric arcs suitable for glass-making. In the types of electric furnaces employed for the production of carborundum and calcium carbide, the operation is generally intermittent, a charge of material being placed in the furnace, the terminals adjusted, and the current turned on until the operation is completed, ofter which the mass is permitted to cool, and removed for a fresh run. Various attempts have been made to construct continuous electric furnaces, especially for the production of calcium carbide, but as yet these are not in commercial and practical service. Dr. Bermbach gives the general arrangement of such a furnace, showing how the crushed and mixed material is fed in a continuous stream, the fused glass being drawn off in like manner. The furnace contains three electric arcs, arranged in succession along an inclined plane, each arc having a sort of pocket below it, in which the fused mass can collect and overflow to the next one. The crushed materials are fused between the terminals of the first arc, and are more thoroughly mixed in their passage to the second, while the final fusion in the third arc effects the production of the very fluid glass, which is delivered into a collecting pot, from which it can be taken at once for manufacture of any desired articles.

American Methods.—It seems that American bicycle manufacturers cannot do better than closely copy British types. As imitation is the sincerest flattery, this may be gratifying news; but for callous candour the following extract from an official report by Mr. Marshal Halstead, the U.S. Consul at Birmingham, bearing the heading "Consular Plan in Export Trade," can, we think, hardly be beaten. We publish it without comment:—"A few weeks ago a young American business man called at the consulate to tell me that one American firm, at least, had followed my plan in export trade, and had been wonderfully successful in doing so. I understand that my caller had read and approved of those portions of

my trade reports where, in entire agreement with all of my consular colleagues, I have urged that American manufacturers study and regard not only the needs, but even the whims, of foreign consumers; and that having ample capital and a good working partner, he had put the idea into successful operation. The firm has about eight agencies. In each contract there is a clause binding the manufacturer to make and pack and ship any article in exactly the way the London agent specifies, and no agency is taken from a manufacturer who will not so bind himself in legal form; and the manufacturer is given to understand that this is the most important clause in the contract, and that his personal views on foreign markets are not wanted. As an example, my caller told me that last year he sold in great numbers an American-made bicycle built almost on British lines, with double-tube tire and metal rims, and that for the coming season his bicycles will have exact reproductions of standard British bicycle fittings and Whitworth threads."

Locomotive Steam Distribution.—A very instructive and interesting paper on the distribution of steam in locomotives was recently read before a meeting of the Northwest Railway Club by Mr. H. P. Herr, Division Master Mechanic of the Chicago Great Western Railway, in which the author dwelt on the effect upon the distribution exercised by changing the valve functions, and analysed the main points of importance in valve setting and construction. Coming from a recognised American expert on the subject, his views deserve great attention, and his suggestion with reference to the use of double-ported valves for high speed work is receiving considerable notice, and its value is about to be practically tested on a western road in the United States. The following is a summary of the views expressed by him on the above-mentioned occasion:—(1) The design of valve motion as a whole is as important as any other single element of the locomotive, and in its solution consideration should be given to the nature of the service to which the engine will ultimately be assigned, as outlined in the body of this paper. (2) The distribution of steam at the probable running cut-off is most important for the proper action of the valve motion and its elements. (3) The full gear adjustment should not be allowed to influence the setting of the valve, to the detriment of the running cut-off. (4) A greater reduction of lead than is generally found in practice is advisable, as is also an increased outside lap and travel. (5) Some form of double or multiple-ported valve is valuable, and should be used, especially in high speed work. (6) The Zeuner and harmonic valve diagrams are material aids to the solution of all slide-valve problems.

A Valuable Alloy.—How important a change may be wrought in a metal by the slightest addition of some other substance is perhaps best seen in the startling transformation of iron into steel. Recently, however, magnalium has attracted public attention, and in this alloy also we find another proof of the fact that the results which follow a chemical combination are frequently a surprise to the most erudite chemist. In a German contemporary Mr. Diegel publishes a few facts regarding magnalium that are well worthy of notice. "Magnalium," he says, "works better than aluminium with all cutting tools, including files; but the difference in behaviour is not greatly marked until the proportion of magnesium reaches 14 per cent. Magnalium can only be hammered in the cold if it contains 14 per cent. or less of magnesium. More of the latter makes the alloy brittle, and it breaks under the hammer. With 6 per cent. or less of magnesium, the strength of magnalium can be notably increased by rolling or working in the cold state. With more than 6 per cent. of magnesium, the alloy will not bear hammering when hot. With 2 to 4 per cent of magnesium, however, it can be forged at a temperature of 400 degs. C., just like copper at a red heat. At a dull red heat magnalium separates into its constituents; at a little lower temperature it is brittle. At 570 degs. C. magnalium begins to soften, and at 626 degs. C. it is completely liquid. Diegel states distinctly that magnalium cannot be soldered with a soft solder containing tin in the usual way. It is to be regretted the experiments have shown that magnalium is readily destroyed by salt water. That is sufficient to preclude the alloy from all structures or machinery that have to go to sea.

A Trolley Omnibus Line.—With trolley tramcars we are familiar enough, but how many of our readers have seen a trolley omnibus? Such an omnibus line, however, has recently been opened to traffic by the well-known firm of Siemens & Halske of Berlin, and gives the greatest satisfaction, both to the owners and to the public, It may be mentioned, incidentally, that this German firm of electrical engineers first established an electric tram line, namely, that from Berlin to Lichterfelde, and remained alone in the field even at the first international electrical exhibition ever held—that located at Paris in '81, where they exhibited a short electric tramway line in the exhibition grounds, similar in most respects to the Berlin suburban line just mentioned. The trolley-omnibus line recently opened runs from Königstein to Hulten and Königsbrunn, passing through the beautiful valley of Bielabach, and has a length of nearly 1·2 kilometres. The electric buses can easily pass each other, and any other vehicles on the road. In the former case, it is only necessary to remove the trolley poles and to sever the contact; in the latter case, all that is needed is to steer to one side, as the poles are long enough to allow a side move of three metres from the trolley line. The vehicles hold twenty-one persons, and the speed averages twelve kilometres per hour. Experiments have been made also with trailers for freight, and have given good results. It seems that in that direction promising developments may be expected.

Thermometer for Low Temperatures.—As every gas at the lowest attainable temperatures becomes liquefied, it is impossible to use such gas

as a thermometric substance, and scientists of recent years have been considering the question what other principle might be used for measuring very low temperatures. In the *Comptes Rendus* of the French Academy, Dec. 2nd, 1901, M. H. Pellat proposed the adoption of an apparatus based on the Pelteir effect. In this apparatus he employs an iron-zinc element which possesses a great thermo-electric power at low temperatures. One portion of this element which is to be exposed to the low temperatures to be measured, has the shape of a cylindrical bar about 20 cm. or 30 cm. long with a junction in the middle. This bar is enclosed in a glass tube and is brought into the space, the temperature of which has to be ascertained. A current is then sent through it, sufficient to produce a measurable Pelteir effect, without however, being sufficient to produce any noticeable Joulean heating. The current must be sent through in such a direction that cooling of the junction results, and this cooling is compensated by heat furnished by a small heating coil; so that the resulting difference of temperature, as indicated by two auxiliary thermo-couples, reads zero. According to M. H. Pellat, who enters deeply into the theory of his instrument, at an absolute temperature of 20 degs. the error is so small as not to exceed 1·5 deg.

To Prevent the Freezing of Gas Pipes.—A simple but effective device for preventing the freezing up of gas pipes is described in the *Illustrirte Zeitung für Blechindustrie*, consisting merely in the insertion of a wider piece of pipe just where the conduit issues from the ground or wall. For a conduit of a diameter from $\frac{3}{4}$ to $\frac{1}{2}$ of an inch a length of from 20 cm. to 30 cm. of a pipe 1 in. in diameter suffices. The deposition of the water particles contained in the gas, which on leaving the works have a temperature of about 10 degs. C., naturally takes place just where the gas is subjected to the most abrupt change of temperature—*i.e.* on its issue from the ground. If the external temperature is sufficiently low, the deposited water immediately congeals and clogs the conduit. As soon as the gas has acquired the temperature of the conduit the deposition of water and congealing cease, and this is said to be the case a short distance beyond the first cooling-point. Therefore there should be no congealing beyond the inserted wider piece, and this piece is wide enough to accommodate a thick ice-crust and to still leave a free passage for the gas. As a matter of fact, the principle of this *new method* is already employed in street lamps, and with success. Anyhow, the expense involved is trifling, and it well merits a trial.

British *v.* American Lifts.—Much has of late been written as to British manufacturing firms not being able to compete with America, with the result that large orders, especially for engineering work, have left the country because America was able to give quicker delivery and cheaper price. We are glad, however, to know that many British firms are successfully competing with America and Germany, and are making special arrangements in order to give greater facility for reducing the cost of production and expediting delivery. When the Central London Railway was constructed, all the rolling stock, rails, lifts—in fact nearly all the engineering plant, was imported from America, and when the Company decided on some additional lifts they asked tenders not only from America but also from some British firms, and it is quite refreshing to note that the British firm in this instance has been successful. Messrs. R. Waygood & Co., Limited, of Falmouth Road, London, S.E., have been entrusted with this contract, being able to comply with the special requirements of the Railway Company. We also note with satisfaction that the lifts for the City and South London and the Great Northern and City Railways have been secured by a British firm in face of keen American competition.

A Strange-looking but Highly-efficient Collier.—One of the strangest crafts ever seen is the steamer *Mercedes*, which has been recently built at the yard of the Northumberland Shipbuilding Co., Limited, Howdon-on-Tyne, for a well-known Cardiff firm, for a special charter for carrying coals from Australia to the west coast of America and general cargo to the Chinese ports. This vessel was built with the object of placing into the hands of the owners what might be justly called the finest collier afloat, equipped in the most scientific manner for the very rapid handling and discharging of its cargo. To accomplish this, the engines have been placed right aft and four very large hatchways, not less than 22 ft. wide, are placed upon the flush deck to be worked by derrick posts 40 ft. high from the deck, eight huge derricks carrying four Temperley transporters. The steam gear, says our contemporary, *The Marine Engineer*, from which we have taken the above data, will consist of twelve specially made winches, of the direct-working type, having cylinders 10 ins. by 14 ins. It is anticipated that a cargo of about 7,000 tons can be discharged from this collier in about 16 hours.

High-Capacity Wagons.—In pursuance of the policy of reducing the working expenses by diminishing the train mileage which has been inaugurated by Mr. G. S. Gibb, the general manager, the North-Eastern Railway have placed an order with the Darlington Wagon and Engineering Company, for fifty double-hopper coal wagons, each of 40 tons capacity. These wagons are to be built to the designs of Messrs. Sheffield & Twinberrow, Newcastle-on-Tyne, and will be similar to the 32-ton cars which are now being completed at Darlington to the order of this company, excepting that the height is increased to 10 ft. The wagons are nearly 40 ft. long over buffers by 8 ft. wide, and they are carried on bogie trucks; the hopper doors are worked by means of the gear patented by the designers, permitting the load to be discharged at any desired rate from either or from both hoppers. The tare weight of the new wagons is about 14¼ tons.

Coal Resources of India.—Professor Dunstan, F.R.S., in a paper on "The Coal Resources of India," read at a recent meeting of the Society of Arts, said that India possesses an enormous supply of coal. The most important coalfields are situated in Bengal, Central India, and Assam—all of which are now being very extensively worked. The chief difficulty experienced is the unsatisfactory means of transport, owing to the heavy freight charges and insufficient rolling stock. It remained for the Government to remove these difficulties. Lord George Hamilton, who presided, said that the coal industry of India will undoubtedly develop. It had been suggested that the Government should establish a school for miners. Indian finances had been so satisfactory of late as to make the mouth of England's Chancellor of the Exchequer water, and he hoped that something might be done in the direction suggested.

Atlas Metal.—We are asked to state by the Anti-Friction Alloys Company, Ltd., the sole makers of that deservedly popular anti-friction alloy known under the name of Atlas Metal (W. E. Watson's Brand), that the title of the firm has now been changed to the Atlas Metal and Alloys Company, Ltd. The considerations which actuated the proprietors in making this change were connected with the difficulties many intending purchasers found in associating Atlas Metal (W. E. Watson's Brand) with the old title of the firm. The new title adopted will, however, effectually remove any ambiguity.

Acetylene Black.—In a communication to us on the subject of a paragraph which appeared in our last issue on the above subject, a correspondent refers to the use of the term "self-burning." As he correctly points out, the phenomenon of decomposing compressed acetylene by an incandescent wire or by an electric spark in an enclosed cylinder with no air present can hardly be included in the category of combustion.

The Acetylene Association.—An Association has now been formed for the advancement of acetylene gas engineering and manufacture. Austria, France, Germany, Italy, Switzerland and the United States have already formed important associations specially devoted to the acetylene interests. England, although the last to establish such an association, was the first country in Europe to commercially manufacture carbide of calcium. "The Journal for Acetylene Gas Lighting and Carbide of Calcium Review" is the official organ of the Association. Mr. Lacey Downes is the temporary secretary, and his offices are at 11, Ironmonger Lane, E.C. The subscription for ordinary members is one guinea per annum.

Expansion of Concrete.—Experiments recently made to determine the coefficient of expansion of concrete have developed the conclusion that this coefficient is about 0·0000055 per deg. Fahr. This is for concrete made with broken stone, gravel concrete giving 0·0000054, while for a bar of stone of the kind used in making the concrete the coefficient was 0·0000056, or practically the same as that of the concrete. In making the experiments, a concrete bar 4 ins. diameter and 3 ft. high was set in a steel cylinder having double walls side and bottom to form a complete steel chamber. A standard steel bar—or copper bar in some experiments—was placed beside the concrete bar, and on the two bars rested an optical lever or plate carrying a vertical sighting mirror, which was opposite a glass window in the cylinder. This mirror reflects the reading of a levelling rod placed beside a transit theodolite 30 ft. away. If the concrete and metal bars expanded equally, the mirror would simply move upward vertically and the target reading would not change. With an unequal expansion, however, one end of the lever rises more than the other, and the angular movement of the reflected ray is double that of the mirror or the lever plate to which it is attached. The first readings were taken with the cylinder open and the room cooled. Steam was then admitted to the double shell, and readings were taken at intervals by the instrument.

Automatic Couplers in the United States.—The wonderful results on the universal adoption of these safety appliances in America are, indeed, startling. It has long been known that it has handsomely paid the railroads there to abandon other couplers, many of them quite new, and adopt a single pattern automatic coupler—this from the point of view of saving in time, money, and labour, and greatly improved traffic gives grand results—but it is when we look at the figures concerning life- and limb-saving we begin to understand the immense importance of safety appliances to employés on railways. In 1898 the American Interstate Commission reported as follows: "In 1897 there were 219 less men killed and 4,994 less men injured in coupling and uncoupling cars than in 1893" (the year the Act was passed), "the number of men killed being reduced by one-half, and the number injured by practically one-half." During 1899-1900 this Act of 1893 was rigidly enforced on the railroads, every freight car not so equipped being turned off the lines, with this remarkable result, that this report for the year ending June 30th, 1901, shows the number of men killed in coupling accidents was less by 35 per cent. *than in the preceding year*, and the number injured less by about 52 per cent. Therefore, in spite of more powerful locomotives, far heavier cars, and increased general dangers to the men, coupling accidents in the United States have, inside nine years, been reduced—in killed 65 per cent. and in injured 75 per cent. A more complete vindication of the evidence of Sir Francis Hopwood before the Royal Commission, and a more thorough justification for Mr. Ritchie's Automatic Couplings Bill, hounded out of Parliament by the railway companies, it is impossible to conceive. Are the officials and shareholders of the railways of the United Kingdom incapable of understanding the significance of such facts?

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In this section is presented every month a concise précis of the contents of the leading organs of the technical press and of the proceedings of the learned societies throughout Great Britain, the Continent, and America, and also, in a summarised form, the subject matter of the more important articles appearing therein.

With few exceptions copies of the articles referred to in this section can be supplied by us. Price 1s. 4d.

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ARCHITECTURE AND BUILDING.

1. Construction and Design.

Concrete Production during Frost.—*Important Concrete Construction in Zero Weather.* This heading refers to the steel or concrete construction supporting a large number of cylindrical steel 15½ ft. in diameter and 80 ft. high, in the Eastern Elevator at Buffalo. This support consists of a steel form about 81 ft. wide., 900 ft. long, and is supported 10 ft. above the surface of the ground on the tops of concrete piers, 33 ins. square, and 12½ ft. apart on centres, both transversely and longitudinally. After going into a detailed description of the structural details, the author of the contribution points out the following interesting facts. The concrete was made of 4:7:13 Portland cement, coarse, sharp lake sand, and 1-in. broken stone, and was so strong that a 6-in. cube seven days old was tested up to the capacity of the machine, 150 tons per square foot, without breaking. This concrete had nearly all been mixed in December, 1900, or January, 1901, when the outdoor temperature varied from freezing to 10 degs. below zero, and the work was carried on regardless of the cold. After describing the method employed the author remarks that, from observations of this work, Mr. A. Wilfrid Ransome, the inspector in charge of construction, is convinced that good Portland cement, well made and properly laid, is not at all injured by severe freezing if it is properly protected, and allowed to set uninterruptedly without refreezing after it commences to thaw.—*Engineering Record*, Dec. 7th, p. 553.

Steel Frames.—*A Steel Frame Foundry Building.* Under this heading are described the structural details of the foundry building for the Marine Engine and Machine Company, at Harrison, N.J., which is a one-storey (100 by 168 ft.) fireproof structure with a two-storey (50 by 77½ ft.) annex. It has brick and glass walls, steel framing, and roof trusses, and concrete and steel second-storey floors throughout. The main part has a row of columns built into each side wall and two interior longitudinal rows of columns, 50 ft. apart, dividing it into three aisles, the outer ones being covered by single-pitched roofs of 25 ft. span, and the middle one by a 50-ft. double-pitched roof, having a 9-ft. clerestory on each side. The centre aisle is commanded by one 20-ton and one 30-ton electric girder crane, which travel the whole length of the building; and one side aisle has in every panel between columns a 3-ton girded hand-crane, and on a transverse track, which cantilevers beyond the interior columns into the centre aisle so as to deliver to the electric cranes. The cupolas are located in the other side aisle, and have around them a 25 by 45 ft. second floor, proportioned for very heavy loads. The above data are followed by a concise but clear account of structural peculiarities which cannot be summarised without depriving it of clearness.—*Engineering Record*, Jan. 4th, 1902, pp. 11-13. (Ill.)

CIVIL ENGINEERING.

1. Bridges and Viaducts.

Bridges.—*The Little Calumet River Drawbridge.* Description of a double throughplate girder drawbridge, on which the Illinois Central Railroad crosses the Little Calumet Railroad. The bridge being the farthest up stream of any on the river, it has but rarely to be swung back for launches and small tugs, other vessels very rarely coming up so far as this. *Engineering Record*, Dec. 23rd, pp. 617-19. (Ill.)

Railway Bridges.—*The Railway Bridge over the Godavari River at Rajahmundry, on the East Coast Railway, India.* The article contains information supplementary to that published in a previous contribution regarding this interesting bridge, which carries the East Coast Railway, connecting Calcutta with Madras, across the Godavari at a point some 40 miles from the sea, and three miles higher up stream than the grand irrigation weir constructed by Sir Arthur Cotton in 1852. The bridge comprises 56 spans of 150 ft. and one of 40 ft., the total length being 9,000 ft. between abutments, or 9,096 ft. over all.—*Engineering*, Jan. 10th, 1902, pp. 39, 40. (Ill.)

Concrete Structures for Railways.—An abstract of a paper presented to the Illinois Society of Engineers and Surveyors, by Mr. W. A. Rogers, M. Am. Soc. C.E. The writer especially notes the general increase in the use of masonry structures for temporary wooden bridges and culverts. That iron and steel bridges are everlasting is now an exploded idea, very many of the more important railway lines now constructing masonry arches in place of steel girder spans, where the location is suitable, concrete being the material largely employed. At the present time there are indeed piers and abutments up to 40 ft. high built entirely of Portland cement concrete, and proving to be eminently satisfactory. Concrete is stated to be an ideal form of masonry for arch construction, being especially good for skew arches, avoiding thus the necessity of the cutting of difficult arch stones. The concrete arches are being built in spans of four or five feet up to spans of 100 feet, steel, however, in some form being ordinarily used to reinforce the larger spans. Concrete is also being employed for cinder-pit walls, turn-table pit walls, sewers, all classes of building and bridge foundations, bumping-posts, chimneys and freight-house floors where there is a large amount of trucking. It is also used for the entire walls of depôt and shop buildings. The materials ordinarily utilised in the manufacture are natural and Portland cement, sand, and broken stone, the use of the natural cement, however, being chiefly confined to concrete placed below the surface of the ground in foundations, as its liability to be damaged by the action of frost makes it extremely unwise to employ it where it would be exposed to an extreme temperature. The proportions ordinarily used for natural cement concrete range from one part of natural cement to 1½ parts of sand to 4 parts of broken

stone, to 1 part of cement to 2 parts of sand to 5 parts of broken stone; the proportions generally used in railroad Portland cement concrete work ranging from 1:2¼ to 1:4:9½, depending upon the character of the structure. Sand is ordinarily specified, clean, sharp, and coarse being the qualities generally called for. It is the opinion of the writer, however—borne out by many experiments—that sand containing a moderate amount of clay or loam makes excellent concrete. A very fine sand naturally will not make so strong a concrete as the coarser, sharper kind. Certain railroads substitute screenings obtained from hard crushed limestone with good success, gravel also being employed in place of the sand, the relative proportions of sand and stones in the gravel being determined, and enough broken stone added to make the required proportion of materials. There is a strong tendency towards wet mixing for railway structures, whilst for the ordinary abutment and pier work the practice is working toward concrete without a special mortar facing. Strong emphasis is laid on the importance of properly mixing the materials. The reasons leading to the increasing use of concrete by the railroads may thus be briefly summed up:—(*a*) It can be built with unskilled labour under competent foremen; (*b*) the ease with which the materials can be obtained, and the readiness with which they can be moulded in different forms; (*c*) as in the present condition of the steel market it takes many months to get delivery of steel bridges, concrete arches of long span can be planned, built, and completed long before the steel could be delivered: (*d*) its economy; (*e*) its durability.—*Engineering Record*, Feb. 8th, 1902, pp. 123, 124.

Reinforcing an Undermined Bridge Pier.—Being that of the St. Louis Iron Mountain and Southern Railway Co.'s bridge across the Arkansas River at Little Rock, which has several fixed spans and one swing span, the piers being of stone masonry on timber caissons sunk to rock, about 45 ft. below the low-water line, the pivot pier resting on a timber crib, with its top 1 ft. below low-water and seated on a timber caisson. As the sand washing under the caisson threw the bridge out of line it was decided to stop further displacement by the building of a new caisson around the old one. Built of Southern pine, it consisted in plan of a hollow rectangle having its walls parallel to those of the old caisson, the outer walls being 70 ft. long and 12 ft. distant from the inner ones (which were 32 ft. long and 7 ft. distant from those of the old caisson). As at the pier site the irregular rocky bottom was covered with 5 or 6 ft. of sand (the water being 35 ft. deep, with a swift current and occasional sudden floods), the sinking of the structure became a difficult matter, rendered more especially so by the necessity of constructing it in place around the pivot pier, instead of launching it from shore and floating it. The method of accomplishing this task is very fully described. The spaces between the old and new caissons were afterwards filled with concrete to a height of about 30 ft. above the cutting edge, and all further scouring, settling, or tipping of the pier has by these means been obviated.—*Engineering Record.* Feb. 8th, 1902, pp. 122, 123.

2. Canals, Rivers and Harbours.

Canal Building.—*Electric Ship's Lift at Henrichenburg.* The article deals with the well-known ship's lift in the Dortmund-Ems Canal, situated 9½ miles from the Dortmund terminus at Henrichenburg, where the greatest difference of level occurs, there being a drop of 50 ft. from one to the next level. One of the most important problems to be solved by the builders of the canal was, says the author, how to negotiate this difference of level in the passage to and fro of canal craft without the loss of time attending the passage through a series of locks. The ingenious device finally adopted is the ship's lift above mentioned, in which a large tank, 230 ft. long, 28 ft. wide, and 8 ft. deep, with sufficient water-carrying capacity and span to float canal vessels up to 800 tons displacement, is moved bodily up and down as required by electric power. All possible precautions have been taken to insure safety, and, though the lift has been in operation for two years, it has been running smoothly and without the slightest hitch. Bearing this in mind, and adding to it that the work is done far more economically than would have been the case had any of the older methods been adopted, the article here referred to, and the data it contains, together with several instructive illustrations, will be of interest to most of our readers.—*Engineer*, Jan. 3rd, 1902. (Ill.)

Canal Construction.—*The Isthmian Canal Commission's Explanation of its Choice of Dimensions for the Isthmian Canal.* This is a very interesting portion of the official report, and lucidly explains the reasons for adopting dimensions that can be understood only when taking into consideration the modern progress and modern tendency in the building of both merchant vessels and war vessels. Thus, for instance, the introduction of large ships on so many routes, and the undoubted fact that for long routes and freights that can be quickly handled, large ships are the most economical, gives these ships an importance in determining canal dimensions much greater than their relative number or aggregate tonnage would indicate. A ship drawing 32½ ft. in salt water, which is no longer exceptional, would draw nearly 1 ft. more in fresh water, and requires for safe navigation not less than 35 ft. of water in the canal. This depth is therefore fixed as a minimum in all the channels. In this way are explained all other innovations in the size and dimensions adopted by the Commission.—*Engineering Record*, Jan. 18th, 1902, pp. 54, 55.

MUNICIPAL ENGINEERING.

Bituminous Macadam Pavements.—Being the substance of an address delivered by Mr. Fred J. Warren before the Boston Society of Civil Engineers on January 8th. It deals with the new pavement, which is constructed on a new theory, the bitumen being employed with *hard* stone instead of in combination with fine mineral grains, as in asphalt. This principle enables the new mad construction to overcome 95 per cent. of the causes of failure in the asphalt. As each piece of stone or sand used is encased in the bitumen—the flexibility of which mortar protects it in a thoroughly efficient manner—and as the various particles of crushed stone are cemented firmly together with a rubbery waterproof cement (which causes the whole to be both resistant and elastic), the advantages of the invention can be at once perceived. A perfectly noiseless as well as a comparatively cheap pavement, it has during the past season been laid in seven cities, large contracts being secured for this year. The entire method of construction is fully set forth in the address given.—*Municipal Journal and Engineer*, February, 1902, pp. 55-8.

The Modern Wooden Block Pavement.—An article by P. C. Reilly. It is generally known that the failure of wooden block pavements is due—(*a*) to the employment of an unsuitable kind of timber; (*b*) to the use of an inferior preservative; and (*c*) to imperfect construction. The wood used should be either long leaf yellow pine, tamarack, or fir (in London Swedish deal has been found to last over seven years): whilst the preservative should be one rich in germicidal and non-volatile properties, and one that will not become soluble in or saponify with alkaline waters, or be affected by extremes of temperature. After numerous experiments it has been been found that creosote oil is the best material, this view being confirmed by the United States Department of Agriculture after a thorough examination into the question. Kreodone creosote wooden block pavement—laid in Chicago, Indianapolis, and other cities—is put forward as the ideal kind, it being adapted alike to residential streets and to heavy trafficked thoroughfares. Wooden thoroughfares should be placed upon a concrete foundation.—*Municipal Journal and Engineer*, February, 1902, pp. 64, 65.

ELECTRICAL ENGINEERING.

1. Theory.

Atomic Weights.—*Classification of Atomic Weights.* This is a summary of the literature on the subject that appeared in the last nine months of last year, or, at all events, of the more important publications; and the central problem remains, namely, whether O = 16 is to be retained as the basis, and introduce an alteration only so far as hydrogen is concerned—an alteration, moreover, so insignificant as to render it unnecessary in most cases; or whether a new basis—*i.e.* H = 1,000—is to be adopted, which would render O = 15·88, and require a recalculation of the atomic weights of all the elements, as well as the molecular weights of all combinations, together with

an alteration of the great number of physical constants. These considerations, as well as the fact that a great number of the atomic weights most frequently used are represented by figures that can be given as a round sum, represent the expediency of the retention of O = 16, an expediency which no discussion can shake. The author of the *résumé* is strongly in favour—as are all members of the German Electro-Chemical Society—of retaining O = 16,000.—*Zeitschrift für Elektro-chemie*, Jan. 3rd, 1902, pp. 67, 68.

2. Electro-Chemistry and Metallurgy.

Electroplating.—*Innovations in the Field of Electrolytic Treatment of Surfaces, Electroplating, and Similar Processes.* In this review of modern progress in the branches of electro-chemistry above mentioned the author describes interesting apparatus, patented by M. Boissier, a well-known authority on the subject, used in electroplating; apparatus for the same purpose, designed and patented by Von Potthof, Snyder-a-O., and a very neat process for the production of smooth surfaces by a galvano-plastic method upon castor-rolled plates.—*Zeitschrift für Elektro-chemie*, Feb. 6th, 1902, pp. 82-9. (Ill.)

3. Measuring Instruments and Methods.

4. Dynamos, Motors, and Accessories.

Standardisation.—*Standardisation of Direct-connected Engines and Dynamos.* The article deals with the final report of the Committee on Standardisation of Engines and Dynamos appointed by the American Society of Mechanical Dynamos, for the purpose of determining—(1) the standard sizes of units to be recommended; (2) the corresponding revolutions per minute of these units; (3) the sizes of shafts for the two classes of centre-crank and side-crank engines; (4) the length along the shaft required for the generator; (5) the height of axis or shaft over top of sub-base; (6) the width of top of sub-base; (7) the armature fit; (8) over-load capacity of engines and generators; (9) brush holders; (10) holding-down bolts, keys, and footboard bearings. All these points are dealt with in the report, which affords instructive reading.—*Engineering Record*, Dec. 7th, pp. 549-50.

5. Electric Transmission of Power.

Power Plant.—*The Water-power Plant at Naunawa Falls, N.Y.* Under this heading is published an abstract of a paper presented to the American Society of Mechanical Engineers by Wallace C. Johnson, of Niagara Falls, N.Y., in which the author describes an important and interesting power-plant designed by him, and built under his personal supervision. The water-power used is that of the Raquette River, the second largest water-course of New York State, drawing its water from the Adirondack Mountains, and draining an area of more than 11,000 square miles. This river has a drop of 300 ft. in the first three miles of its course below Cotton, and a further drop of 85 ft. in the next ten miles of its course. The land and water rights along this part of the river have been acquired by the Naunawa Falls Water-power Company, which has begun its operations with the development of the lower 85-ft. fall. The details of these operations are outlined by the author, who gives a full description of the essential parts of the enterprise, whose ultimate object is to supply current for the lighting plant at Potsdam (4½ miles from the station), owned by the company; to supply Cotton (10½ miles from the station), by means of a 20,000-volt high-tension line: and later, Ogdensburg, 19 miles further on.—*Engineering Record*, Dec. 7th, 1901, pp. 576-9.

—— *The Red Bridge Power Station of the Ludlow Manufacturing Company.* Description of works for developing about 5,000 h.p. at Red Bridge, on the Chicopee River, built by the company above named, about four miles from their mills. This water-power will be transmitted electrically to the company's hemp and jute factories, eight in number, and having an aggregate floor space of nearly 620,000 sq. ft., where it will supplement 5,000 h.p. derived from water privileges previously used.—*Engineering Record*, Dec. 28th, 1901, pp. 610-13. (Ill.)

Power Station.—*The New Power Station of the New York Edison Company.* Description of the new generating station which the New York Edison Company were compelled to erect, owing to the increasing demand for the supply of electricity for lighting, manufacturing, and other purposes, this supply, so far as the borough of Manhattan, New York City, is concerned, being practically under the control of the Edison Company. The new station will supplant a good deal of the scattered generating equipment hitherto in use, and in time absorb all of it. The larger stations will probably be converted into sub-stations, where the alternating current to be generated in the new power station, and similar ones to be erected in future, may be converted into direct current for the supply of the three-wire direct-current distributing system, by means of which most of the electricity is delivered.—*Engineering Record*, Jan. 4, 1902, pp. 3-8. (Ill.)

6. Electric Lighting and Heating.

7. Telegraphy and Telephony.

Progress in Telephony.—*National Telephone Co.'s New Battersea Exchange.* Description of the above-named exchange, opened quite recently and being equipped in the most "up-to-date" style. Thus, for instance, it possesses a lamp-signal switch-board, working on the Kellog central-battery-system of the latest type, and the only one, so far, to be seen in Europe. The operating, with reference to the subscribers, is similar to that used in connection with the Western Electric Company's system. The calling lamp is acted upon the moment the subscriber removes his telephone from the switch hook. In front of each pair of cords there are two clearing lamps, of which the front one is actuated by the called-up subscriber when he is hanging up his telephone, and the one behind by the subscriber who asked for connection being made, when he does the same. The article enters into a full description of the construction and the working of the switch-board, which considerably differs from what we have been, so far, accustomed to in England.—*Electrician*, Feb. 7th, pp. 603-5. (Ill.)

Wireless Telegraphy.—*A New System of Wireless Telegraphy.* Under this heading is given the description of relay devised by M. Axel Orling, a young Swedish electrician, and Mr. J. T. Armstrong, a well-known London engineer, for which its inventors claim that it is absolutely original, and has no connection with the systems devised by Marconi, Tesla, and others. They have given to the product of their common ingenuity the somewhat grotesque name of Armorl, and state that the relay is sensitive up to 0·003 volt. The principle on which it is based is that of the capillary electrometer. It consists of an inverted U-tube containing mercury, one end being immersed in a mercury reservoir, while the other, which is drawn to a fine point, is cut off so near the end that the opening is not more than about 0·004 in. This end dips into a bath of diluted acid. Close to this point is one end of a lever, the middle of which rests on a knife edge, while the other end is movable between the two contacts of the local circuit. The height of the mercury in the reservoir is such that the pressure exercised by it is just balanced by the capillary force at the point of the tube. The current enters at the top of the bend of the U-tube and passes out at the diluted acid bath. The moment a small current passes, the capillary force decreases and the mercury begins to drop from the tube, but stops again as soon as the current ceases. When the mercury falls on the end of the lever, it tips the latter and closes the local circuit.—*Electricity*, Dec. 6th, 1901, pp. 678-9, and Dec. 13th, 1901, p. 681.

8. Materials and Methods for Conducting Currents.

Wire Cleaning.—*A New Automatic Wire Rejuvenator Used in Brooklyn.* This device is intended to be a saving to all electric street railway companies, in so far as it renders as good as new wire that heretofore had to be scrapped. Formerly it was practically impossible to rewind field-coils after they had once been burned out, and there was no alternative but to employ new wire. Mr. E. Chamberlin, Superintendent of Equipment of the Brooklyn Heights Railway Company, who, together with his general foreman Mr. George C. Murray, has invented and patented the above device, has rendered the rewinding quite feasible at a minimum expenditure. By his method the wire is first heated in an oven, so as to char thoroughly the insulating material. After this the wire is

drawn through a machine specially designed for that purpose, in which wooden blocks first remove the charred insulation and then clean the wire, which thereupon passes through a pair of buffers, consisting of several soft wire brushes, which give a nice polish to the cleaned wire. It is then drawn through the centre of a hollow winding head, and finally reaches the binding-drum, serving to pull it through the apparatus, having received four or five turns around the binding-drum, and is then carried to the winding-spool, upon which it is tightly coiled and receives the customary appearance. An automatic shifting guide serves the purpose of guiding the wire, so that it is deposited in even layers upon the spool.—*Street Railway Journal*, Dec., 1901, pp. 528-9. (Ill.)

9. Electric Traction.

Interurban Tramways.—*The Milan-Monza Interurban Tramway.* This heading refers to a road connecting the two cities above-named, which has a length of 10½ miles, including 2 miles of city track belonging to the local tramway system of Milan, the owners of the latter being also proprietors of the interurban section. The author of the article refers at some length to the bond used, which is identical with that employed in Milan in the last five years, and which has given, it appears, very satisfactory results. The system employed is the overhead system, two No. 00 trolley wires being used, which for the greater part of the distance are supported by iron bracket poles. These poles are made of two U-shaped beams, connected with a very light lattice-work. The power for working the line is derived from the same hydraulic plant which supplies the Milan-Edison Co. There is also a storage battery employed in parallel with the rotary transformers. There are three of the latter, reducing the tension from 15,000 volts. to 330 volts. The makers are Messrs. Ganz & Co., of Buda-Pest.—*Street Railway Journal*, Dec., 1901, pp. 515-18. (Ill.)

10. Miscellaneous.

Cranes.—*Electric Crane.* This is the heading of a concise account of an electrically-worked jib crane, erected on the Town Quay at Southampton, which contains a number of features not met with in the other cranes there installed. Thus, while the cranes previously erected ran on wide-gauge rails and were all mounted on high gantries, so as to permit the traffic to pass beneath them, the new crane is, for special reasons, mounted on a low truck, fitted to run on the standard rail gauge (4 ft. 8½ ins.) and provided with the ordinary buffers, so that it can be shunted about by a locomotive. The shape of the jib is such as to give it as great a clearance as possible for working over the sides of ships; the method of raising employed renders it very stiff, and the structure is mostly composed of wrought steel. These and other features are given in the periodical mentioned below; and a general view of the crane, with the side of the crane-house removed, so that the gear may be seen, is an aid to the reader.—*Engineer*, Jan. 3rd, 1902. (Ill.)

MARINE AND NAVAL ENGINEERING.

1. War Vessels.

Ship Figureheads.—*Figurehead and Ornaments for the U.S. Cruiser Cincinnati.* Under this heading is given a short account of the U.S. cruiser *Cincinnati*, in which the time-honoured custom of endowing vessels with a figurehead has been revived. The advent of steel vessels had brought with it the abolition of the characteristic figureheads of former ages, when vessels were wooden structures. The cruiser above named was built at the New York Navy Yard in 1893-4; her sister ship, *Raleigh*, was built at the same time at the Norfolk Yard. These two vessels, together with the *Texas* and the first *Maine*, were the only ships in the modern steel navy built in the government navy yards. The *Cincinnati* is a second-class cruiser with a length of 800 ft., beam of 42 ft., draft of 18 ft., displacement of 3,186 tons, i.h.p. designed, 110,000 tons. The power intended for the *Cincinnati* was very large, and with Scotch boilers it led to a crowding of machinery not conducive to the highest efficiency under running conditions. There were, besides, some other small defects in the equipment, and, in consequence thereof, shortly after the Spanish-American war, it was decided to replace the Scotch boilers in the *Cincinnati* with water-tube boilers, and to make some other changes, most noteworthy of the latter being the replacement of wood in the furniture of the vessel with non-combustible material. It was on that occasion that the idea suggested itself of reviving the custom of ornamenting all vessels with a figurehead. In the present case the life-size figure of "Liberty," together with the ornamental work, was designed and constructed at the New York Navy Yard by Rear-Admiral Bowles, and the excellent effect produced can be seen at a glance in the illustration accompanying the short account here referred to.—*Marine Engineering*, Dec., 1901, pp. 530-1. (Ill.)

Submarine Boats.—*Some Experiments with Wireless Telegraphy.* The bulk of the article printed under the above heading is devoted to a description of a new type of submarine boats designed by Messrs. Orling and Armstrong—the inventors of the "Armorl" system of wireless telegraphy—the motors of which can be controlled, if desired, from a battleship. The new craft has conning towers fore and aft, and at the base of one of these is the receiving instrument which controls the movement of the rudder. For propelling there is a single screw which may be driven by whatever power seems most suitable under the given circumstances. The importance of the fact that the submarine boat can be controlled from outside can hardly be overrated, as up to the present the greatest obstacle to the usefulness of this kind of craft is the difficulty with which the commander of such a vessel has to pick his way. Many devices, it is true, have been tested—notably optical ones—by which it was supposed that the appearance of the surface of the water could be communicated to the navigators while many feet below, but none of them has proved reliable. The ideal solution of the problem, therefore, is one in which the control or steering of the vessel is left to persons who have a full survey of the ocean surface and the horizon. The device for transmitting the direction from the battleship to the submarine is simple. In the conning tower of the battleship is a small wheel similar to that used for steering the vessel. This wheel is connected with the "Armorl" instruments, and whenever certain movements are made with this wheel, a corresponding group of electric currents are generated and transmitted to the water by wires which act in precisely the same way as the two iron stakes used in connection with the "Armorl" method, when transmitting messages overland. Since water, however, is a much more sensitive conductor than earth, the electric oscillations can travel in it a much greater distance without losing their intensity. Moreover, in the water no especial system of gathering the oscillations has to be employed, and however deeply the submarine boat may be submerged beneath the surface the electro-capillary relay of the receiver in the boat will feel the electric discharges, provided, of course, the receiver in the submerged vessel is synchronised with the transmitter on the battleship. Considering these facts and many others specified in the acticle referred to, Messrs. Orling and Armstrong appear to have added another formidable weapon, be it for offence or defence, to the many that have made their appearance within the last twenty-five years.—*Scientific American*, Jan 18th, 1902, pp. 40-41. (Ill.)

2. Freight and Passenger Vessels.

Turbine Steamers. — *Turbine Steamer King Edward.* By W. Cartlie Wallace. In this article the author gives a very full description of the passenger steamer *King Edward*, which was placed upon the Clyde during the early days of the Glasgow Exhibition. Without, however, giving a detailed account of the Parson's turbine, the application of which to the driving of electrical generators, as he justly remarks, dates back to more than a decade, and the general principles of which are known to every engineer, he emphasises the great improvements that have been made since its first appearance, and which have transformed the steam-engine—specially distinguished by its lavish use of steam without an equivalent return of force—into one of the most economical engines in existence. Since a turbine engine cannot be indicated, other measurements of its efficiency have to be used, the simplest and most accurate of which is the determination of the amount of electrical energy developed in a dynamo when coupled directly to a turbine motor. In this way was recently tested a turbo-alternator manufactured at Heaton Works, Newcastle-on-Tyne, for the corporation of Elberfeld, in Germany, which was

witnessed by a committee of experts. The results obtained proved the turbo-alternator to be, without a shadow of a doubt, the most economical of all engines driven by steam power.—*Marine Engineering*, January, 1902, pp. 8-12. (Ill.)

3. Pleasure Boats.

4. Engines and Equipment.

Electrical Appliances Aboard Ship.—*Martin's Electrical Specialties for Steamships.* The above-named Glasgow firm make a specialty of electrical appliances for steamships, specimens of which were shown at the Glasgow Exhibition last year. The contribution here referred to is practically a short account of the exhibit, giving prominence to a few devices distinguished by novelty and efficiency. Among the latter is mentioned a small enclosed high-speed engine and dynamo suitable for lighting steam yachts, designed to give a maximum of output for a minimum of weight and space. Another noteworthy and interesting device is Messrs. Martin & Co.'s automatic duplex system of electric mast and side lights. Since the introduction of electric light to the signal lamps of steamers this automatic indicator fulfils an important function. Incandescent electric lamps fitted in these lanterns in the ordinary way are liable to give out at any moment, and until the officer on watch happens to notice the accident the ship is running the risk of collision. The automatic indicator designed by Messrs. W. C. Martin & Co., which is usually fixed in the chart room, prevents this risk, since the failure of any one of the lamps is made known by means of a bell, which keeps ringing until the lamp in question has been attended to. At the same time, however, the lantern does not remain dark, for a reserved filament is automatically brought into the circuit, and the light in the lantern remains continuous: while simultaneously a lamp is lighted in the indicator behind a glass corresponding in colour to that of the signal lamp that demands attention. —*Steamship*, January, 1902, pp. 245-51. (Ill.)

MECHANICAL ENGINEERING.

1. Boilers, Furnaces and Fuel.

Megass as Fuel.—*Furnaces for Burning Megass.* The contribution published under this heading contains a description of various types of furnaces commonly met with in the West Indies, adapted to the burning of fresh or green megass, the refuse of the sugar cane as it comes from the mill, and then gives an account of some boilers with furnaces installed by him which embody the principles which he believes to be the correct ones. These boilers were a large Stirling boiler and two multitubulars. With his installation the sugar and run were made entirely without coal, and with addition only of a small quantity of wood; and even this latter, according to his view, would have been unnecessary had the mill been a better one: while on an adjoining estate similarly equipped, excepting the boiler and chimney, the fuel consumption is equal to quite 6 cwt. of coal per ton of sugar, the height and dimensions of the chimney playing, in the author's view, an essential part.—*Power*, January, 1902, pp. 14, 15. (Ill.)

Beaumont Oil Tested as Fuel.—This report of the fuel value of crude petroleum from the Export Oil and Pipe Line Co., of Beaumont, Texas, is furnished by Prof. James E. Denton, Professor of Mechanical Engineering, Stevens Institute of Technology, Hoboken, N.J., a comparison being instituted between the oil and buckwheat coal, in which the strong superiority of the oil fuel was clearly demonstrated. A horizontal return tubular boiler was employed, evaporative tests at various horse-powers being made. As an instance, it was found that the time to raise 85 lbs. of steam was 59 minutes for the oil fuel, whilst with a coal fire steam was raised in one hour and seventeen minutes. As a result the conclusion may be drawn that for a range of from 112 to 220 h.p. the total evaporation from and at 212 degs. per lb. of oil varied from 15·71 to 15·29 lbs. of dry steam, the burner consumption varying from 3·1 to 4·8 per cent. of the boiler output, so that the net evaporation ranged from 14·74 to 15·16 lbs. of water per lb. of oil. The evaporation from and at 212 degs. per lb. of coal was 9·17 and 8·94 lbs. of water for 93 and 119 h.p. The coal afforded 11·16 per cent. of ash, and 14,680 B.T.U. per lb. of combustible when burned in oxygen in a calorimeter (representing an excellent No. 1 buckwheat). The combustion of the oil by the burner was practically perfect. The cost of handling the oil is less than coal for machinery, but of course the ground space required for underground storage tanks is more expensive.—*Engineering and Mining Journal*, Feb. 1st, 1902, pp. 169-73.

2. Engines and Motors.

A Successful Wave Motor.—*The Santa Cruz Wave Motor.* By H. W. H. Penniman. Description of what probably is the only practical and successful wave motor in existence. Most attempts to harness the irresistible power of the ocean and to force it into the service of man have failed; others have succeeded for a short time, until the first severe storm shattered the work of human hand; but the wave motor here referred to, situated near the city of Santa Cruz, California, has stood the test of four years. On the so-called Cliff Drive, where rugged sandstone bluff rise in some places sheer 50 ft. from the breakers below, tunnelled and worn by the ceaseless swell of the open Pacific, at a point unprotected by outlying rocks or shoals, two wells, eight and five feet in diameter respectively, were sunk in the cliff, one behind the other, the foremost but five feet from the brink. These wells extend from 30 ft. above high tide to below the ebb, and open at the bottom in the ocean. A counterbalanced float rises and falls between vertical guides in the foremost well as the swells outside raise or lower the water level. The plunger of a common force-pump working in any part of a long pump barrel occupies the second well, forcing on the down stroke the salt water vertically 120 ft. to a 5,000 gallon tank raised on a 60 ft. derrick on the bank above, whence it runs to tanks along the country roads for miles around, and is used for sprinkling purposes. In ordinary weather the pump fills the supply tank in about one hour. It is intended to utilise the surplus in future for the manufacture of salt. There are given in the description, a number of interesting details showing the remarkable simplicity of the motor, which, at all events, proves the feasibility of rendering serviceable the force of the rhythmical swell of the ocean, and the Santa Cruz motor may ultimately become a useful prototype.—*Scientific American*, January, 1902, p. 8. (Ill.)

Motors.—*The International Kerosene Oil Motor.* The title refers to a novel type of motor which can be run by kerosene instead of gasolene, and in which, moreover, a fertile source of trouble, the electric spark, has become unnecessary. The inventor, Mr. H. G. Underwood, had in view the aim of constructing an engine for auto-motor vehicles which should be as simple and practical as possible in construction and operation, and at the same time be much smaller in size, lighter in weight, and, if possible, more compact than any other engine in the market. The engine is constructed on the two-cycle principle, and all valves are dispensed with by employing the piston to open and close the exhaust and inlet parts in the usual manner. The essential details are fully explained in the article. The consumption of fuel is very small, a pint an hour per horse-power is all that is required, and with the prices of kerosene in the United States, a 2½ h.-p. motor can be kept going all day for a shilling. The makers are The International Power Vehicle Company, of Stamford, Connecticut, U.S.A. (Ill.)

Motor Vehicles.—*War Office Trials.* Under this heading a very full account is given of the very interesting experiments inaugurated by the War Office in December last at Aldershot. These trials have shown, says the writer of the introductory leaderettes, that at least two engineering firms are at present capable of building self-propelled lorries capable of carrying loads of five tons over all sorts of roads, and practically across country, preserving an average speed of between five and six miles per hour, and giving in every way the most complete satisfaction. The trials were exceedingly severe, and if only two of the competing lorries emerged from them with full honours, the misfortunes preventing some of the others from being equally successful were such that the builders of these cars will find no difficulty in removing the causes.—*Auto-motor and Horseless Vehicles Journal*, Jan. 15th, 1902, pp. 137-55. (Ill.)

REVIEWS.

The History of the Midland Railway.—By Clement E. Stretton. Methuen and Co., 1901. Demy 8vo, 358 pp., 100 illus., 12*s.* 6*d.*

This volume records the progress of the Midland system from its birth, under the title of the Leicester and Swannington line in 1830, to the present day. It will doubtless be welcomed by the ever-widening circle of readers interested in our railways, and also by those who, from their residence in the Midland Counties, have been more or less closely in touch with the line and its far-sighted administrators.

The thirty-two chapters teem with information and anecdotes relating to the various troubles and successes of this admirably managed and progressive system, which has, since its formation, absorbed at various times no less than thirty-two independent undertakings, and, in addition, has a joint interest with various companies in nineteen other lines.

It seems hardly possible that less than seventy years since, a train should be stopped in a tunnel and the word passed down from carriage to carriage "It's only the chimney that has caught the top of the tunnel, that is all."

This occurred at the opening of the Leicester and Swannington line, which rejoiced in some primitive signalling arrangements worked in one case by the wife of a platelayer, and in another by an innkeeper.

The permanent way consisted of wrought iron fish-bellied rails, 15 ft. in length, weighing 35 lbs. per yard, as against the 36 ft. steel rails weighing 100 lbs. per yard in use at the present time, while the engine cylinders were 12 ins. diameter and 16 ins. stroke, the steam pressure 50 lbs. per sq. in., and the weight of the engine and tender 13 tons.

To-day the same class of Midland engines have cylinders 19½ ins. diameter, 26 ins. stroke, 180 lbs. pressure, and a total weight of 103 tons.

It is interesting to note that whistles or steam-trumpets were first used on this line, and were of somewhat extravagant dimensions—18 ins. high, and 6 ins. diameter at the top!

To the Midland belongs the credit of running the first excursion train; this took place in July, 1840, but it was, of course, the late Thomas Cook who built up the excursion business, and his first train was run from Leicester to Loughborough a year later, the fare charged being one shilling; the excursion fare which the Midland charges for the same journey at the present time.

Excursions by rail in these palmy days attracted considerable attention, 20,000 spectators assembling at Sheffield to witness the departure of a train made up of 5 engines and 47 coaches containing some 2,000 persons.

In 1844, the North Midland, Midland Counties, and Birmingham and Derby Junction Companies, were amalgamated under the title of the Midland Railway, and George Hudson "The railway king," became chairman. The career of this remarkable man receives attention in a later chapter, and should not be overlooked.

Want of space precludes reference to many interesting occurrences, but the suggested amalgamation of the Midland, the London and North Western, and the Great Northern, calls for some notice.

This combination was proposed in 1852, as the two latter railways were anxious to prevent the further growth of the Midland system, which then ended at Rugby. Terms were agreed to between the several companies, and a bill was brought before Parliament to enable this arrangement to be carried into effect. It did not, however, receive the sanction of the House, although backed by powerful influences, and the scheme thus ended in failure.

About this time increased traffic on the London and North-Western caused serious delays to the Midland, which sent its south-bound traffic over the former line from Rugby, and in 1857 a line was completed between Leicester and Hitchin by means of which the Midland was able to run a through service to King's Cross, thus obtaining its first direct hold on London traffic.

Running powers are, however, as the author remarks, more or less illusory; since the company granting the powers is always in a position to cause delays and inconveniences. The usual solution of the matter is, therefore, the construction of a separate line. This was the experience of the Midland, as, in 1862, 3,400 of its trains were delayed on the Great Northern owing to the dislocation of traffic caused by the Great Exhibition.

In addition its expresses were compelled to follow the slow trains of the latter company, and the climax was reached when its rolling stock was summarily "evicted" from the Great Northern sidings at King's Cross. The directors then determined to build a line of their own from Bedford to St. Pancras, and to make provision for four sets of metals—a wise policy for which the present proprietors have every reason to be thankful.

This extension is well described in chapters xx. and xxi., as is also St. Pancras Station, with its magnificent span of 240 ft., the reasons which necessitated the method of construction employed being fully set out. It was opened for traffic in 1868. The following chapters deal with most noteworthy matters of policy.

In 1872 the Midland directorate gave notice that third-class passengers would be carried by all their trains, and this was followed two years later by the abolition of the second-class.

It is difficult to over-estimate the effect of these "master-strokes" of railway statesmanship, which at that time gave rise to no little uproar. The company was, in fact, petitioned by the other leading railways to postpone its action, and a retaliatory policy was threatened; but the Midland stuck to its guns, and thus laid "the foundations of a magnificent prosperity." The same year witnessed the introduction of Pullman cars to this country, which were run between St. Pancras and Manchester; but the "Manchester man" expressed so decided a preference for the compartment system that the cars were withdrawn. The company, however, was not discouraged, and in later years pioneered the adoption of first and third-class breakfast and dining cars.

In chapter xxiv. the extension from Settle to Carlisle is reviewed at some length. This line was put in hand owing to the delays experienced in the working of the Midland's North-bound traffic, which was then run over the London and North-Western metals from Ingleton. The engineering difficulties met with in the construction of this 72 miles of road involved works of some magnitude, as in addition to the Batty Moss Viaduct—1328 ft. in length and 100 ft. high—and the Blea Moor tunnel, there were in one section of 20 miles, 47 cuttings, 5 viaducts, 4 tunnels, and 68 under bridges.

The expenditure on this portion of the system amounted to £3,467,000, and it was without doubt the greatest development of the Midland policy of extension, with the exception of the line from Bedford to London, though the Forth Bridge, in which the Midland has the largest interest, and the Heysham Harbour Works should not be forgotten in this connection.

Having recorded the progress of this splendid corporation in an easy and attractive style, Mr. Stretton enlarges upon the Derby Locomotive Works, and on the construction of the company's rolling stock; lamenting the while that it is no longer possible to adhere to Stephenson's rule, that no gradient should exceed 1 in 330!

Concluding chapters of the book are devoted to the administration of the company, and give many interesting details of its working. The summarised biographies of the various chairmen deserve special attention, and the notices of the chief officials and their duties contain information of considerable value.

The history of the Midland Railway is, in fact, a distinct acquisition to our railway literature, and the qualifications of the author render criticism superfluous. Mr. Stretton's name is well known in connection with railway matters, as is also his *penchant* for accuracy. In addition, it is hardly an exaggeration to say that he has for years past acted as the unofficial chronicler of the Midland's triumphs and trials, so that the compilation of this volume could not have been placed in better hands. There is ample evidence in its pages that the author's task has been a labour of love, in which he has been well seconded by the publishers.

The Economic Disposal of Town's Refuse.—By W. Francis Goodrich, A.I.Mech.E. London: P. S. King & Son. 1901. Demy 8vo, 340 pp., 75 illus. 10*s.* 6*d.* net.

Refuse destructors, like the poor, are always *en évidence;* their advocates are many and strenuous, so also have been their revilers, who would do well to peruse Mr. Goodrich's compilation, which contains a mass of facts and figures sufficient to convert the most conscientious objector to the adoption of the only sanitary method of refuse disposal.

Although destructors have been in use for the last five-and-twenty years, it is but seldom that the resolution of a town council to purchase a site for an installation of this character meets with unqualified approval. The atmosphere in the vicinity of the site will, it is asserted, be poisoned with noxious gases and dust, in short, the plant will be a perfect nuisance. It should be a well-known fact that such statements are now both worthless and misleading.

The book consists of twenty-five chapters, the first of which describes the evolution of refuse destructors, while the two following sections stigmatise in vigorous language the filthy system of refuse tipping, sorting and utilisation, the two latter operations being well described as "trying to save something that isn't worth having after it is saved." It is amusing to read that in 1694 the mayor of an important borough in the South of England was fined 6*s.* 8*d.* for depositing refuse in front of an inn. The borough in question has now spent many thousands of pounds on electric lighting works and tramways, but it is still without a destructor. What a beautiful example of municipal fatuity!—and there are others. The disgusting method of dumping refuse on low-lying land, which, in the fulness of time, is advertised as an "eligible building site," has its peculiar advantages.

After devoting a couple of pages to the legal aspect of the collection and disposal of refuse, Chapter V. deals with the value of town's refuse for steam raising, and Chapters VI. and VII. with the comparative efficiency of boilers for destructor plants, and slow *versus* rapid combustion.

The author states that specially good refuse may be found within 50 to 70 miles of our coal-fields, but he has also found refuse of excellent calorific value in one of the "decaying" industrial centres of East Anglia. The term "decaying," by the way, is hardly applicable to any industrial centre in the Eastern Counties.

Considerable emphasis is placed upon the fact that the primary duty of a destructor is to destroy, in a thoroughly efficient manner without nuisance; but the author's suspicions of the non-steam-raising destructor are no doubt well founded, for it is only reasonable to conclude that if refuse is thoroughly burnt at a high temperature, good steam-raising results will follow as a necessary corollary. The theory put forward in certain quarters not so many years since that no steam-raising destructor could possibly cremate refuse in an efficient manner should have been decently buried long ago, but from time to time there are evidences which show that this weakly child still lightly draws its breath.

The author's comments on the various types of boilers in use with destructor plants do not call for extended notice; the large steam and water space of the Lancashire boiler is referred to as rendering it specially adapted for this class of work. Water-tube boilers are, however, extensively used, owing to their quick steam-raising qualities, large heating surface and compactness.

A word of warning is given as to the necessity of providing pure feed water for these boilers, but the author's views on water purification appear somewhat fossilised; the time has passed to talk of anti-incrustators, and the efficiency of the apparatus described for cleaning boilers is highly problematical. At its best it is but an inadequate substitute for a softening process. It is strange to find an engineer advocating the use of an appliance

for removing scale in these days of high pressures: it should not and need not be allowed to form.

The author remarks that it is not advisable to coal-fire boilers through which gases from destructor cells are passing, owing to the inrush of air; this difficulty might perhaps be obviated by the use of mechanical stokers, but in the case of large destructor plants worked in conjunction with an electricity supply station it is certainly preferable to have separate coal-fired boilers.

The suggestion that both the cells and boilers of such a plant should be duplicated in order to facilitate flue cleaning and inspection is magnificent —but it is not business. The successful operation of several large power destructors shows that duplication of the cells is unnecessary, and would needlessly increase the capital outlay.

The remainder of Chapter VII. contains specifications for Lancashire and water-tube boilers, and some useful notes on their construction and management.

The two following sections on boiler-setting, flues, chimney-shafts and draught, will repay perusal. The author draws attention to the loss of efficiency caused by faulty boiler-setting, and remarks that a number of practical boiler-setters have made a good living by altering work of this nature originally carried out by local bricklayers. He emphasises the importance of arranging for flues of large sectional area, the provision of manholes, and for the effectual interception of flue dust; but the illustration given of the exterior of a dust catcher does not convey the slightest idea of its construction, further than the fact that it is not unlike a large beehive. The arrangement has, however, proved extremely satisfactory in practice, and the patient reader will in due course arrive at a sectional illustration, 224 pages further on.

Mr. Goodrich's experience with dampers, the *bête noir* of destructor engineers, has apparently been a happy one, as he merely states that the ordinary counter-balanced damper is the most reliable, and does not give much trouble; as to water-cooled dampers he is silent.

The comparison between the heights of the chimney shafts of the low temperature destructors and the present-day forced draught plants is well shown by a chart. The heights of the former shafts vary from 300 ft. to 120 ft., while the latter range from 100 ft. to 45 ft. The saving in capital outlay is of course considerable, but of far greater importance is the increased efficiency secured. In fact, the advent of forced draught undoubtedly "stopped the rot" in refuse destructors, as the author somewhat inelegantly remarks.

The progress of the combined destructor and electricity works equipped with a shaft only 80 ft. in height will be watched with interest. The additional coal-fired boilers will presumably be fitted with forced draught as well as the destructor cells. The author has a strong preference for steam jet blowers as against fans for producing forced draught, but it is doubtful if the former arrangement is as efficient; the percentage of steam used by the blowers to the total steam raised comes out in one test at about 40 per cent. This is a result which requires some explanation, and cannot be taken as an average figure; 15 per cent. would be a great deal nearer the mark. The author remarks that the guaranteed evaporation of the plant should be exclusive of the steam required for the fan or blowers, which seems fairly self-evident. He adds, in a way that is childlike and bland, "No doubt some will think such a requirement bordering on the ridiculous"—they must be destructor patentees. Personally he thinks the requirement justifiable. This is refreshing, as he is connected with a firm of destructor manufacturers, though it is only fair to say that he does not show any *undue* preference for their type of plant in his remarks. His idea of reducing the height of the firebrick lining of the shaft, or altogether dispensing with it, in cases in which the heat from the cells is fully utilised, does, however, border on the ridiculous.

The next six chapters deal with the methods of refuse disposal employed in London and throughout the United Kingdom, detailing the progress made in this direction, the present position of the matter and the population of each town, together with the cost and type of the plant installed (if any) and the results of a number of tests.

These statistics are arranged in a handy form, though a few misprints have crept in, as is unavoidable; the population of Woodbridge, for instance, is not 14,000, but no matter; these figures will be exceedingly useful to the members of local authorities and their surveyors, since many towns of relatively small size are considering the advisability of erecting destructors and utilising the steam raised for electric lighting, sewage pumping, and other purposes. It is unnecessary to comment here upon the results obtained from the working of destructors, as the subject has already been ably dealt with in the columns of FEILDEN'S MAGAZINE, in addition to which it would be impossible to discuss the matter at sufficient length within the space of this review. It is of interest to note that there are at present 106 plants in operation in England and Wales, 24 of which are in or near London, 6 in Scotland, and 3 in Ireland.

Further, it is an indisputable fact that Great Britain stands well ahead of anything that has been accomplished elsewhere in the construction of destructor plants and in the results obtained.

The description of the smallest destructor in the world should not be overlooked. It is erected at Hunstanton, and burns 3½ tons of refuse *per diem*, providing sufficient steam to pump the water supply of the district. The population of the town is given as 1,322.

The remainder of this exhaustive volume deals with refuse disposal in North and South America, Europe, India, South Africa, and Australasia, and describes in detail the various types of destructors referred to in earlier chapters. The book will be of considerable service to all in search of information on these unjustly maligned appliances.

A destructor plant is one of the best securities in which any town can invest, and it is to be hoped that the arguments adduced by Mr. Goodrich may carry due weight with our sanitary authorities.